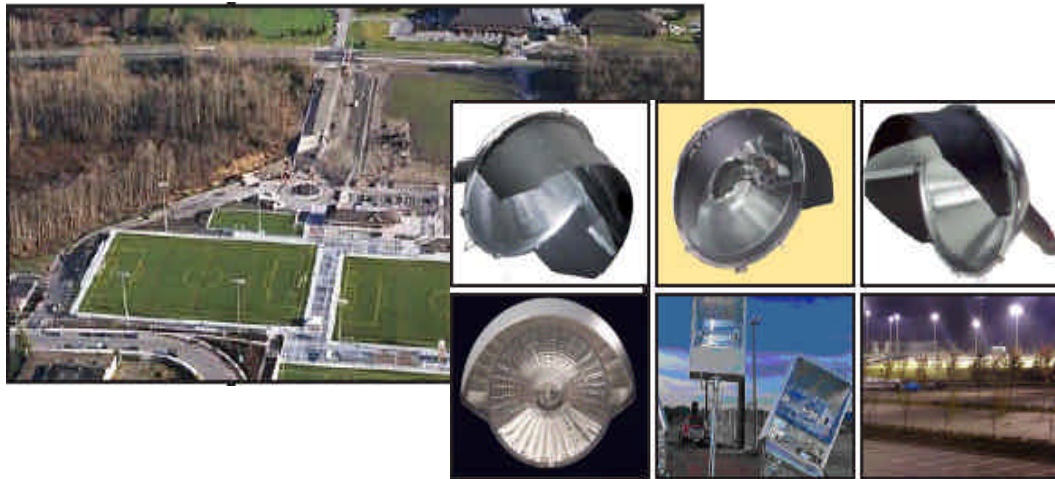




Athletic Field Lighting Technical Report



Prepared for:

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August 8, 2005
SWSG Project No. 04-148

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EXECUTIVE SUMMARY

In November 2004, Shaffer, Wilson, Sarver & Gray, P.C. (SWSG) was tasked by the Fairfax County Park Authority (FCPA) to provide electrical engineering services to research and identify the current state of athletic-field lighting systems for inclusion in a comparative-analysis study. The leading sports lighting vendors identified in this study will provide Fairfax County with options for future projects that will be both sensitive to the environment and suitable in terms of cost and performance. Additionally, SWSG was tasked to develop generic technical specifications for use by Fairfax County in future athletic-field lighting projects.

SWSG retained the services of DMD & Associates (DMD), an electrical consulting firm specializing in sports lighting systems, to assist with this study. The study conducted by SWSG and DMD addresses the following items:

1. Development of criteria for an objective review, comparison and evaluation of leading sports-lighting systems.
2. Identification of prospective sports -lighting system manufacturers marketing in the Fairfax County area.
3. Review of any potential future impact of the International Dark-Sky Association (IDA) requirements with respect to obtrusive light from sports-lighting installations.
4. Review of Fairfax County lighting ordinances with respect to sports lighting.
5. Review, comparison and evaluation of current sports -lighting systems.
6. Development of updated standard specifications for future sports -lighting projects.

This study addresses baseball/softball and soccer/football facilities only and does not address other outdoor sports-lighting installations such as tennis, golf, etc.

SWSG invited leading sports -lighting vendors to perform product presentations in SWSG's office. This allowed us to review their technical specifications, which became the basis for the comparison analysis and for the creation of the technical specifications. Presentations were made by Hubbell, Musco, Qualite and Soft Lighting Systems

Three other manufacturers were contacted to participate in this project. General Electric declined to participate, and Zone Lighting has no representation on the East Coast. Despite numerous requests for detailed information, Universal Lighting did not furnish us with sufficient information about their products and, therefore, has been excluded from the product comparison.

SWSG and DMD developed criteria to compare technical data furnished by various vendors. The criteria and the ranking system that followed are presented in the body of this report.

SWSG understands the sensitive nature of comparing products by competing vendors that may later result in a selection of one over the other. SWSG and DMD paid strict attention to impartiality in both communicating with vendors and in preparation of this report and prepared Impartiality Statements that were given to Fairfax County for the record. During the process of data collection for this project, SWSG and DMD were asked to sign Confidentiality Agreements with the individual vendors. It is our obligation not to disclose this confidential information. Copies of the agreements are kept in our records.

This study is organized into various sections, the highlights of which are:

Fundamental Concepts Related to Sports Lighting

This portion of the study establishes the basis for performing an objective review, comparison and evaluation of sports -lighting equipment and includes a review of the concepts that must be considered when designing a sports -lighting facility.

Industry Standards and Documents Related to Sports Lighting

Sports field lighting systems are designed and evaluated based on existing standards that are readily available and generally accepted. These standards are:

- Illuminating Engineering Society of North America (IESNA).
 - Sports and Recreational Area Lighting (IESNA RP-6)
 - Lighting for Exterior Environments (IESNA RP-33)
 - Guide for Photometric Measurements of Area and Sports Lighting Installations (IESNA LM -5)
 - Light Trespass: Research, Results and Recommendations (IESNA TM-11)
- National Little League Association Standards and Safety Audit

With respect to the standards listed above, we recommend the following:

1. IESNA Class of Play System and corresponding lighting levels be adopted for design standards.
2. Spill light standards be addressed through the application of TM-11 and RP-33 with respect to maximum allowable levels of spill light.
3. Glare be controlled by limiting the amount of candela from the worst-case aimed fixture to 12,000 cd (calculated). The City of Seattle has established this standard for their parks. We find this level of glare to be achievable and that it produces a positive result when compared with designs that have no glare criteria.
4. Sky glow be controlled by using fixtures with external shielding and proper mounting heights to limit the amount of light cast into the air by the fixtures to a maximum of 5.0 percent of candela from total lamp lumens at 90 degrees from nadir.
5. Standards and processes for designing sports lighting in Fairfax County be reviewed on a regular basis to keep up with emerging technology. We suggest a review of these standards in 5 to 7 years.

Comparison Matrix

The team of SWSG and DMD formulated a weighted scoring matrix to evaluate and compare the various sports field lighting systems.

Some of the more important aspects of sports lighting systems evaluated in this matrix are:

- Lighting Performance
- Luminaire Mounting and Aiming
- Lamp, Ballast and Ballast Enclosure
- Foundations, Poles and Crossarms Assembly
- Service and Warranty
- Controls

Life-Cycle Analysis

The life-cycle cost comparison is provided for an anticipated life cycle of 30 years. The cost comparison includes an evaluation of:

- Capital costs - Equipment and installation costs.

- Maintenance costs - Cost of regular lamp replacement and cleaning of the luminaries.
- Operations costs - Energy costs.

Recommendations

Most of the products evaluated are capable of providing adequate lighting to meet the recommended practice for typical baseball/softball and soccer sport fields. However, both the performance and costs of the products do vary.

Our recommendations, as detailed in this report, are summarized below.

1. Illuminating Engineers Society of North America (IESNA) specifications shall become the standard for on-field performance, and that a qualified engineer with IESNA experience shall be retained to prepare the design and provide performance testing.
2. With respect to off-field lighting performance, we recommend the following:
 - That spill light shall be limited to the maximum allowed by IESNA publications TM-11 and RP-33 using the methods for measurement outlined in these publications.
 - That glare shall be controlled by limiting the amount of candlepower as calculated from the worst-case aimed fixture.
 - That sky glow shall be controlled by limiting the amount of uplight from the fixtures to that allowed from an IESNA cutoff classification.
3. The standards and process for sports lighting design shall be reviewed and updated on a 5- to 7-year basis as new technologies and processes are being developed.
4. Componentized packaged systems that feature factory preassembly, factory testing and factory aiming of luminaries shall be specified, since these products provide superior value.
5. Corrosion-resistant materials be specified for equipment and that ballast enclosures be constructed from powder-coated aluminum for reduced maintenance.
6. Specification of features that enable ease of maintenance. We recommend that a cost-and-benefit analysis of purchasing extended warranties be conducted on a per-project basis to determine the best value for the County.
7. Specifications for remote controls shall be based on the needs of the project rather than a standard remote control across-the-board.
8. Different methods for obtaining energy efficiency shall be evaluated when reviewing project proposals.
9. Life-cycle costs for competing systems shall be evaluated on a project-by-project basis under competitive bidding.
10. Development of generic technical specifications for sports lighting systems for FCPA to be used on future projects.

FUNDAMENTAL CONCEPTS RELATED TO SPORTS LIGHTING

This portion of the study establishes the basis for performing an objective review, comparison and evaluation of sports lighting equipment, and includes a review of the concepts that must be considered when designing a sports lighting facility.

Sports field lighting installations typically involve banks of high wattage lights mounted on tall poles positioned around a defined playfield. The goal of the sports lighting system is to enable safe nighttime play. This extension of playtime through illumination increases the number of hours the field can be used, reducing the total number of fields an owner must develop to accommodate demand for play and maximizing the owner's return on investment.

For those not experienced in lighting design, the terminology can be confusing and complicated. To aid in this study, the SWSG/DMD team has developed a basic explanation of lighting issues and terminology as they relate to sports field lighting.

DEFINITIONS

The following definitions will assist the reader in understanding the basic units used in sports lighting.

Lumens

An electric lamp produces radiant energy in the form of light. This “luminous flux” is expressed in lumens. The total amount of luminous flux generated by a lamp is used in photometric reports for lighting design.

Intensity (Candlepower)

Sports lighting fixtures (and many other fixtures, as well) use reflectors to concentrate the luminous flux from a lamp in a specific direction. This concentration of the luminous flux is expressed in candlepower or candelas (cd). If the intensity values from a fixture are known in many directions, the light distribution of a fixture is known.

Illuminance

Illuminance is the density or quantity of light falling (incident) on a surface. The more lumens landing on a surface, the higher the illuminance. The unit of illuminance is expressed in footcandles (American measurement system) or lux (metric measurement system). A footcandle (fc) is defined as one lumen uniformly distributed over an area of one square foot. A lux is defined as one lumen uniformly distributed over one square meter. Illuminance is inversely proportional to the square of the distance between the light source and the surface. That is, the farther the surface intercepting a beam of light is away the light source, the lower the illuminance.

Luminance

Luminance is concentration of light reflected toward the eye per unit area of surface. Luminance is what the eye sees, and is expressed in candela per meter squared (cd/m^2). Designers are able to describe the intensity of a light in a given direction by calculating the candelas, estimating the relative brightness of an object or light source as observed from a defined location.

The four fundamental quantities described above are illustrated in the *Figure 2-1 – Lighting Terminology*. By remembering this illustration much of the mystery of photometric terminology disappears.

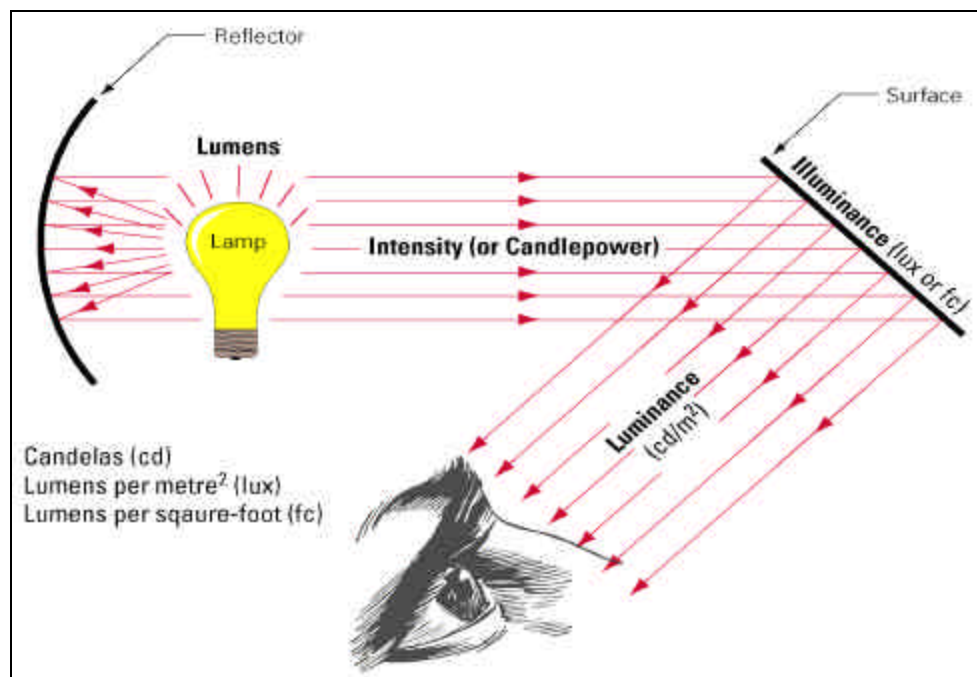


Figure 2-1 – Lighting Terminology

Uniformity

Uniformity is a calculation of relationships of illuminances over an area. In effect, the uniformity expresses the “evenness” of the light within a defined area. Uniformity is often used to express the “quality” of light for an installation even though a strict view of quality might include other variables such as color temperature.

Obtrusive Light

Obtrusive light is a growing concern with regard to all lighting installations. Sports lighting installations are often targeted with respect to obtrusive light since they are often the most intensely lighted facilities in a community.

Obtrusive light consists of three interrelated elements, each considered separately. The three elements include spill light, glare and sky glow. The three elements of obtrusive light are shown in *Figure 2-2 – Obtrusive Light Components*.

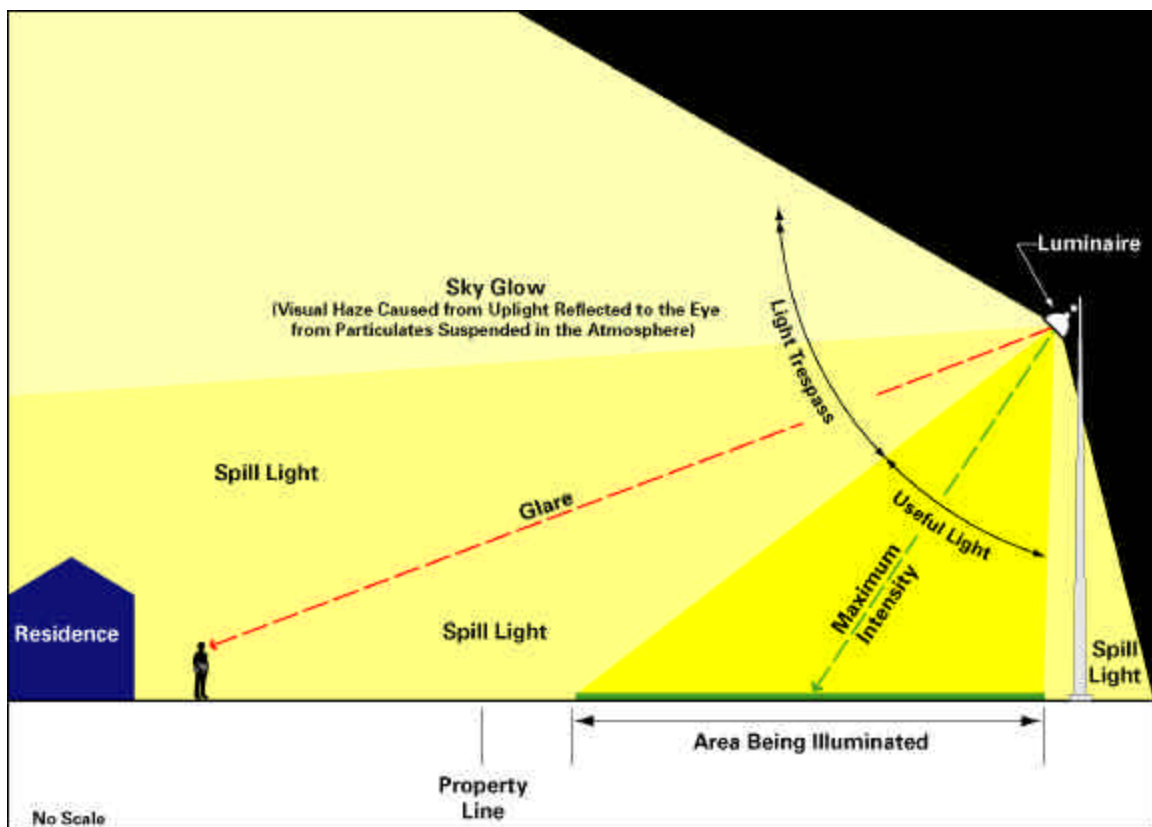


Figure 2-2 – Obtrusive Light Components

Spill Light

Spill light is any light that falls beyond the area that is being illuminated. Spill light is also known as light trespass. Spill light is measured and expressed in fc, and is typically measured and calculated in the vertical plane at the edge of private property where occupied by residents.

Lighting organizations, such as the International Dark-Sky Association (IDA) and the Illuminating Engineers Society of North America (IESNA) have defined maximum levels of spill light within given areas of ambient brightness. Known as Lighting Environmental Zones (LEZs), these area classifications are being recognized and defined by professional organizations.

Areas are classified into one of four LEZs, ranging from LEZ 1, the most restrictive, to LEZ 4, the least restrictive. Since it is nearly impossible to contain all light from an outdoor lighting installation within the area intended to be lighted, a certain amount of spill light onto adjacent properties is inevitable. The maximum amount of spill light for each LEZ is shown in *Table 2-1 – Maximum Amount of Spill Light for Lighting Environmental Zones*. These maximums shall be measured at 1.5 m above grade at the residential boundary line with the light meter oriented at the brightest bank of lights.

Pre-curfew shall apply to sports lighting which is not in operation for the entire evening. Post curfew levels are therefore not applicable as they apply to lighting systems which operates from dawn to dusk. IESNA definitions for LEZ's are typically very general and not tailored for any one specific type of outdoor lighting. With respect to sports lighting we recommend an LEZ 3 be applied to a rural type land use and LEZ 4 applied an urban land use. LEZ 1 and 2 should not be applied to sports lighting.

Designation	Brightness Classification	Recommended Maximum Illuminance Level (Ee)	
		Pre-Curfew	Post-Curfew
LEZ 1	Intrinsically dark areas of minimum ambient brightness	0.1 fc / 1.0 lux	0.0 fc / 0.0 lux
LEZ 2	Areas of low ambient brightness	0.3 fc / 3.0 lux	0.1 fc / 1.0 lux
LEZ 3	Areas of medium ambient brightness.	0.8 fc / 8.0 lux	0.3 fc / 3.0 lux
LEZ 4	Areas of high ambient brightness	1.5 fc / 15.0 lux	0.6 fc / 6.0 lux

Table 2-1 – Maximum Amount of Spill Light for Lighting Environmental Zones.

It is important to note that the maximum vertical illumination levels that define spill light are based on research using human subjects where a cross section of individuals was subjected to various levels of light in controlled situations. This research and the corresponding maximum levels are therefore based on human sensitivity to light and are applicable in areas and situations of human habitation. These requirements should not be applied to situations where insects, plants, animals or other environmental issues are the chief concern as this research is not related to those situations.

Although spill light should generally be controlled in residential scenarios where people reside, reactions to spill light often varies. Some residents are ambivalent with regard to spill light, or may even prefer spill light on their property to enhance their feeling of security, while other residents want the spill light directed away from their property.

Glare

Glare is light that hinders or bothers the human eye. Direct glare from a light source is typically an important issue in the design and operation of sports field lighting installations, both in terms of the players and nearby populations. Glare can be so extreme as to become discomforting or even disabling. Glare is typically expressed in cd/m^2 .

- **Disability Glare** is the presence of an amount of glare so significant as to prevent an individual from seeing adequately. An example of disability glare is the reduction in visibility for a driver caused by the headlights of an oncoming car.
- **Discomfort Glare** is the presence of glare that causes a sense of pain or annoyance, and may increase blink rate or even cause tears. The exact cause of discomfort glare is not known.
- **Nuisance Glare** is the presence of a sufficient amount of glare as to be bothersome but does not prevent vision or lead to discomfort. An example of nuisance glare might be the presence of a light source that can be viewed from a distance (such as street light) but does not affect one's ability to see. The fact that it is within your field of view may attract your attention. This is nuisance glare.

Because glare depends on a number of factors, including factors of the human condition, its description is highly subjective. Although glare has been studied by lighting professionals and ophthalmologists for over 100 years, its practical measurement has not been established. In fact, when a cross section of individuals are exposed to the same amount of glare, each individual may have a different opinion of whether they consider the situation to be disabling, discomforting, or simply annoying.

Sky Glow

Sky glow is the haze or glow of light emitted above the lighting installation and reduces the ability to view the darkened nighttime sky. The source of sky glow is a combination of light emitted upwards from a light source and reflected light cast upwards from the surface being illuminated. Sky glow is only present (and its effect of brightening the night sky present) when light is reflected off particles suspended in the atmosphere. If the atmosphere has a large quantity of suspended particles (dust, pollution or moisture, for instance), sky glow will be more pronounced. There is no accepted measurement for sky glow on a project level.

Sky glow can be minimized by reducing the amount of light cast into the sky directly from luminaires. Cutoff refers to the ability of a fixture to control the amount of intensity (candlepower) emitted by a fixture at designated angles above nadir (vertical). A high level of cutoff typically results in lower levels of sky glow and may reduce off site glare. The Illuminating Engineers Society of North America (IESNA) has established a formal system for classifying fixture cutoff.

IESNA cutoff designations are illustrated in *Figure 2-3 – IESNA Cutoff Classifications*.

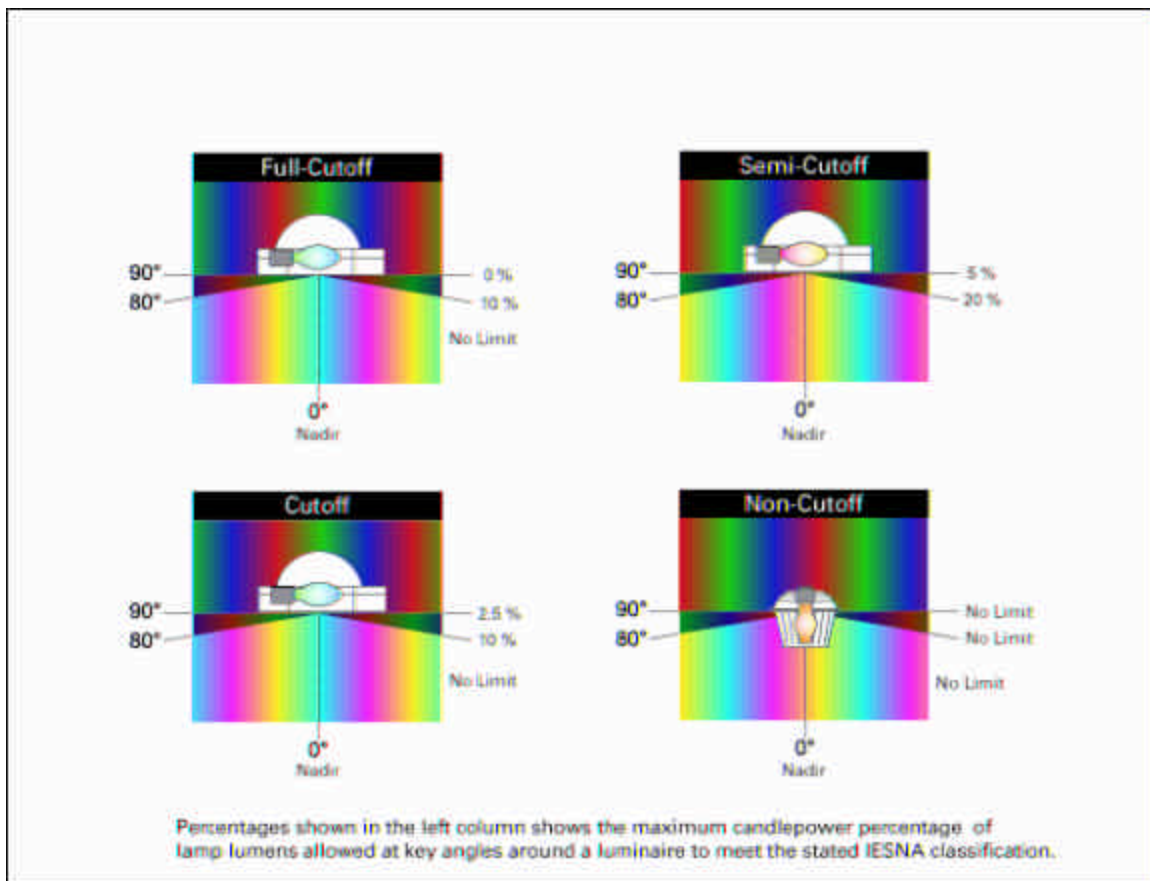


Figure 2-3 – IESNA Cutoff Classifications

Full-Cutoff – A light distribution where zero candela intensity (no light) occurs at angles 90 degrees above nadir. Additionally the candela per 1000 lumens does not numerically exceed 100 (10 percent) at a vertical angle of 80 degrees from nadir.

Cutoff – A light distribution where the candela per 1000 lumens does not numerically exceed 25 (2.5 percent) at angles 90 degrees above nadir, and at 100 (10 percent) at an angle of 80 degrees above nadir.

Semi-Cutoff – A light distribution where the candela per 1000 lumens does not numerically exceed 50 (5 percent) at angles 90 degrees above nadir, and at 200 (20 percent) at an angle of 80 degrees above nadir.

Non-Cutoff – A luminaire light distribution where there are no candela limitations in the zones above maximum candela angle

Very few sports lighting luminaires are formally classified as full-cutoff, or cutoff according to IESNA definitions; however, proper downward aiming can result in performance similar to various IESNA cutoff classifications and assist in minimizing sky glow and reducing off site glare. Proper downward aiming is a product of defining the suitable pole height in combination with luminaires with external shielding to achieve full cut-off or cut-off benefits.

Figure 2-4 – Cutoff Comparison of Sports Lighting Fixture with Downward Aiming on the next page illustrates the benefits of using taller poles to improve downward aiming.

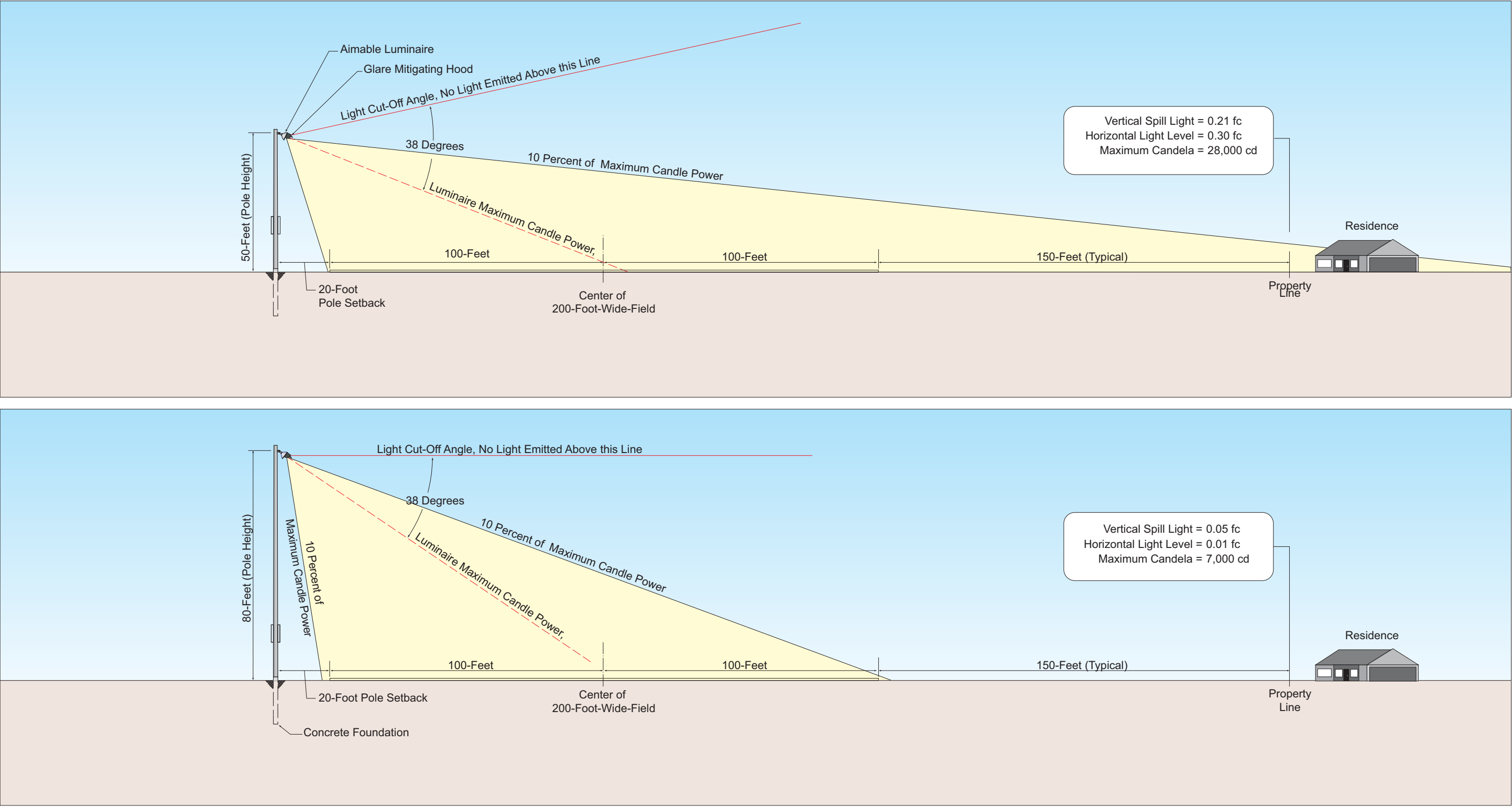


Figure 2-4 – Cutoff Comparison of Sports Lighting Fixture with Downward Aiming

DESIGN CONSIDERATION

The items discussed in this section relate to the design of the illumination system for sports field lighting.

Sports field lighting systems are individually designed, both in terms of the electrical and illumination systems.

LUMINAIRE

Luminaire Beam Spreads

Sports field lighting luminaires are typically supplied from the manufacturer with beam spread information that describes how the light is actually distributed by the fixture. A beam spread is determined from the luminaire candlepower distribution pattern excluding all candlepower lower than 10 percent of the maximum intensity. The National Electrical Manufacturer's Association (NEMA) has developed a standard classification system for beam spread that is used by the sports field lighting industry. Luminaire beam types are classified by NEMA as Type 1 to Type 7, with the narrowest beam being Type 1 and the widest being Type 7. Narrow beams are typically used to distribute the light in a narrow area over long distances, and wider beams are typically used to distribute the light over wider areas and shorter distances. Typically NEMA Types 3, 4 and 5 beam spreads are used for sports field lighting. Use of narrow beam fixtures may adversely affect uniformity by creating "hotspots." If narrow beam fixtures are used, the calculation grid for illuminance should be tightened to a maximum of 10-feet to identify hotspots.

Sports Lighting Measurements and Calculations

This section describes the types of measurements and calculations required to design a sports lighting system. These include horizontal and vertical illuminance, uniformity calculations and glare calculations.

Calculation and measurements of illuminance and calculation of uniformity require establishing a grid to establish the points of measurement or calculation. These grids are defined in IESNA publications RP-6, *Sports Lighting and Recreational Area Lighting* (RP-6), and LM-5, *Photometric Measurement of Area and Sports Lighting* (LM-5).

The light level for each point on the grid is calculated by the designer using lighting design software.

Horizontal Illuminance

Sports lighting design for recreational-level sports complexes is typically limited to calculations and measurements of illuminance. Due to a variety of recoverable and non-recoverable light loss factors, including lamp lumen depreciation, sports lighting fixtures degrade in their light output over time. Because of this, two illuminance calculations are required for a sports lighting design – an initial illuminance level, and a minimum maintained illuminance level that takes into account all light loss factors. The light level for each point on the horizontal grid is calculated by the designer using lighting design software, and the mean value is determined.

The Initial Average Illuminance is the average illuminance on the specified plane when the lighting system is new. This value is important, because it allows the system to be field tested shortly after construction to determine if it meets specifications. The initial average illuminance is the value expected after the lamps have burned for 100 hours to ensure that they are stabilized. If the initial average illuminance is not calculated by the designer, it can be determined by using the minimum maintained average illuminance and applying the light loss factors.

The lowest average illuminance on the specified plane that should be experienced is known as the Minimum Maintained Average Illuminance. Once this illuminance level is reached, the sports lighting fixtures will need to be cleaned and relamped. The minimum maintained average illuminance is the typical performance criteria specified by the engineer.

Illuminance values for various sports in North America are established by the IESNA in RP-6.

Vertical Illuminance

Vertical illuminance calculations and measurements are required for spill light, as well as for considerations for television coverage (an area outside the scope of this report).

Research findings indicate that horizontal spill light (that is, light measured with the meter photocell receptor parallel to the ground) is not the key objectionable component with respect to spill light. Rather, vertical illuminance perpendicular to the line of sight is the most significant issue. Measurements, known as eye illuminance (E_e), have therefore become the standard for evaluating spill light.

The measurement of spill light can be undertaken with a calibrated illuminance meter by taking measurements at the property line or other vertical plane established to define where light trespass occurs at 30-foot intervals. To block out extraneous light, a shielding cone is attached over meter's photocell receptor. The E_e measurement is accomplished by orienting the shielded meter's receptor toward the source of the objectionable light at a height of five feet to six feet above grade in the z axis (the approximate height of the eye) and recording the illuminance reading in lux. By comparing the reading to the applicable values for the proper LEZ the designer is able to confirm if a light trespass noncompliance issue may exist.

Uniformity Calculations

Uniformity is important for sports lighting as an object (a ball, for example) traveling from areas of varying illuminance may appear to change speed. Uniformity is calculated from the values measured or calculated on the grid established for the field.

Methods to calculate uniformity for sports lighting typically include maximum-to-minimum (max to min) and coefficient of variation (CV).

The max to min calculation is performed by establishing both the maximum and minimum illuminance level, and dividing the maximum value by the minimum value. The uniformity is expressed as a ratio (e.g., 3.0:1).

The CV calculation uses a statistical method to express the weighted average of all relevant illuminance values. It is the ratio of the standard deviation for all illuminance values to the mean illuminance value, and is expressed as a decimal number (e.g., 0.13).

Max to min and CV values for various sports in North America are established by the IESNA in RP-6.

Measurement of Illuminance

Illuminance is measured with an illuminance meter. Horizontal illuminance is measured with the meter level with the field surface, and the meter receptor positioned at 36 inches above the field surface.

Figure 2-5 – Measuring Illuminance illustrates how a lighting technician measures horizontal and vertical illuminance levels when verifying a sports field lighting installation.



Figure 2-5 – Measuring Illuminance

Glare Calculations

No generally established methods for calculating acceptable levels of glare have been established in the sports lighting industry; however it is possible to compare and analyze fixtures at the design stage.

As part of the luminaire and mounting height selection process, it is recommended that the lighting designer should review the supplier's luminaire candlepower curves and select the appropriate luminaire mounting height and optical system so that no greater than 12,000 candlepower from any given luminaire is visible from beyond the residential property line. Determining the angle between the maximum candlepower and the 12,000 candlepower line will check this calculation. This angle can then be applied to the aiming point on the area being lighted to determine where the 12,000 candlepower level cuts off relative to the residential boundary. This is illustrated in *Figure 2-6 – Glare Calculation*.

This method of using the luminaire supplier's candlepower curves to access glare is a common sense approach for assessing glare as part of the design. It is however not practical or necessary to field measure the candlepower as the candlepower curves are based on independently measured luminaire photometric's. The 12,000 candlepower level is the level recommended by DMD based on professional judgment and assessment of over a hundred installations over the last 10 years. This level has no real scientific basis other than the satisfaction of local residents when the levels are below 12,000 candlepower. The *Institute of Lighting Engineers (England)* published "Guidance Notes for the Reduction of Light Pollution" in 2000 which define maximum candlepower of 30,000 for an L3 or L4 LEZ. 12,000 is achievable with suitable luminaire optics and mounting height.

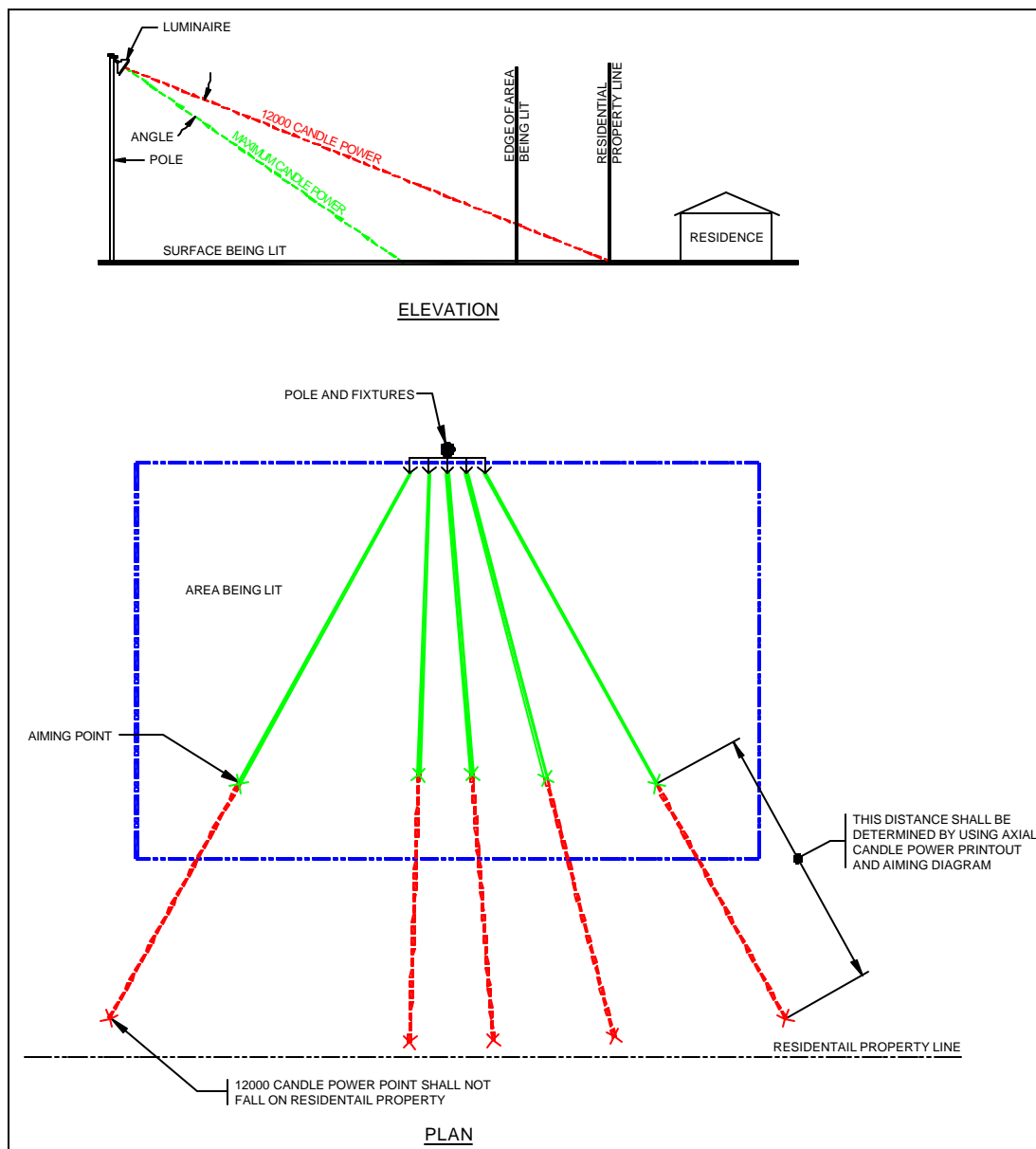


Figure 2-6 – Glare Calculation

Energy Conservation

Energy consumption is a major consideration for sports lighting. Depending on prevailing local rates and the tendency for rates to trend upward over time, energy costs may equal or even exceed sports lighting system capital costs over the life of a sports lighting system. For the owner to receive best value, the design engineer should calculate the energy consumption for different sports lighting systems under consideration.

From a design standpoint, energy conservation can be maximized through the following considerations.

- **Use of Efficient Fixtures.** Not all sports lighting fixtures provide the same level of light control, and inefficient fixtures will waste light (and the energy used to produce it) by casting it off site and/or into the air. It takes more inefficient fixtures to light a field to the required levels. This means an owner who uses

less efficient fixtures will pay more both in capital costs (more fixtures) and in energy costs (more watts used).

- **Do Not Over Light.** Lighting designs should meet minimum criteria, but should not exceed the amount of light required for the field programming. In the past lighting designers have tended to over light fields by as much as 20 percent or more to allow for competition among bidders or to overcome unknown field conditions. These strategies cost field owners money in wasted energy every time the lighting system is energized. Today's computer software and the expertise of sports lighting specialists means fields can be lighted to proper levels for the level of play.
- **Install and Use Controls to Provide Lights Only When Needed.** Designers should provide control systems that energize the lights only when they are needed and at the level needed, and turn the lights off when not needed. Desirable features include remote control switching, tracking of sunset to provide lighting only during the hours of darkness, desktop scheduling, and considerations that do not energize the lights in the case of rainouts or last minute forfeiture. Well-designed and implemented controls not only save energy, but also reduce labor costs.
- **Install and Use Dimming and Switching Systems.** Different levels of play have different recommended lighting levels. Different sports may use different portions of a field for play. Use of dimming systems means recommended lighting levels can be provided for each level of play, saving valuable energy. By developing the electrical system to accommodate switching, some luminaires can be left off if only a portion of a field is being used (such as a soccer overlay in the outfield of a baseball facility). Dimming and switching should be integrated with the facility's control system.

Light Sources and Wattage

High intensity discharge light sources are recommended for sports field lighting due to long life, energy efficiency when compared to incandescent sources, and high luminous efficacy. Every manufacturer of outdoor sports lighting fixtures uses HID sources.

Metal halide (MH) lamps have become the standard light source for sports field lighting, and are recommended due to their good color rendering and superior optical control characteristics. Recent advances in technology, however, may result in additional light source choices becoming available such as induction lamps or sulfur lamps. Light emitting diodes, while not currently feasible for sports lighting, may become a viable light source some time in the future.

High pressure sodium (HPS) lamps are not recommended for sports lighting due to their poor color rendering.

SPORTS LIGHTING POLES

Poles are a major component of a sports lighting system. Selection of the luminaire mounting height number and placement of poles can have major impacts on the effectiveness of the lighting system and on control of obtrusive light. Pole shall be sized so fixtures are never aimed more than 65 degree above nadir. This will ensure suitable downward aiming for on field playability. Off-site spill light and glare requirements will often require lesser aiming angles to reduce impacts on local residents.

There is no established method for determining the number of poles needed to light a sports field as each situation will be different. Typical layouts are provided in RP-6. In general, the larger the field the more poles are needed. Baseball/softball fields, for instance, can be lighted with as few as four poles for a field with a 200-foot outfield, but may require as many as eight poles for a larger outfield (400 ft plus outfield).

A major consideration with respect to pole placement is on-field glare which could negatively affect the player's view. *Figure 2-7 – Glare Zones for Soccer Fields* illustrates this concept, which also applies baseball and most other outdoor sports.

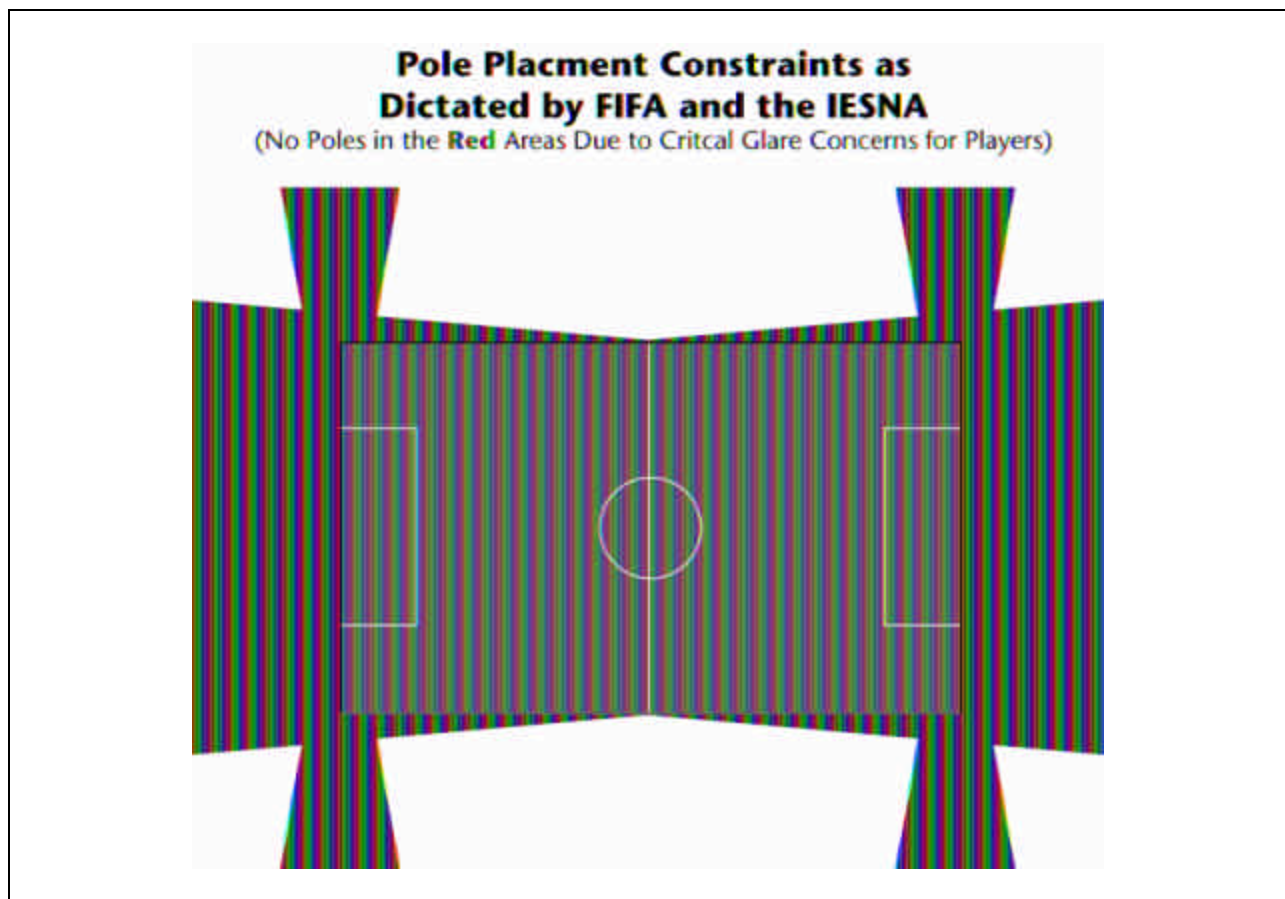


Figure 2-7 – Glare Zones for Soccer Fields

Based on the play characteristics of individual sports, glare zones where poles should not be installed have been identified in RP-6. For soccer, for instance, luminaires are not allowed in the mouth of the goal or areas where corner kicks take place. Glare zones for baseball and softball are even more numerous due to the added

complexities with respect to the location of bases where a great deal of play takes place. These glare zones relate to on-field play only, not offsite glare.

Poles for sports field lighting installations are generally galvanized steel, wood or concrete. An analysis of each type includes the following.

Galvanized Steel

These poles are generally tapered from top to bottom and supplied in multiple sections that slip together on site. The smaller slip fit sections make for easy shipping and storage. According to published data from the American Galvanizers Association, a galvanized steel pole will have a service life of well over 50 years. Another advantage is that wiring can be installed and protected inside the poles. Steel poles can be supplied in heights of 200-feet or more. Twisting and bending of steel poles is not a concern. Steel poles can be direct buried (if properly treated and imbedded in concrete) or installed on a concrete base and attached with anchor bolts. Poles with anchor bolts will require a base plate on the pole. We consider galvanized steel the preferred material for sports lighting poles.

If done properly, painting a galvanized steel pole should extend its life. Typically the benefits of painting do not equal the additional capital cost. A steel pole is subject to corrosion from the inside at the base plate or direct bury portion. These factors have a greater impact on the pole than whether paint is used or not. When painted, the preparation of a galvanized steel pole involves sandblasting off some of the galvanizing to achieve acceptable paint adhesion. This is a very intricate process and if not done properly can reduce the effectiveness of the galvanizing. Where painting is required for aesthetic reasons, we recommend a powder finish and well-defined specifications for applying and testing paint adhesion.

Concrete Poles

These poles are tapered from bottom to top and supplied in a single section. One-piece construction limits the size of the poles to approximately 100-feet-tall. The inside of the pole can be used as a wireway in a fashion similar to steel poles. Concrete poles are typically direct buried. Twisting and bending of these poles is not a concern. Service life is similar to steel. Concrete poles are more expensive to supply and install than steel, but offer attractive finish options such as exposed aggregate.

Wood Poles

These poles are tapered from bottom to top and supplied in a single section. Wood is subject to rot, twisting and bending which poses significant problems for sportsfield lighting over the life of the system. The bending and twisting significantly affects precise fixture aiming, reducing the quality of the lighting system and increasing the likelihood of light trespass anomalies not anticipated in the initial design. The service life of wood is less than steel or concrete. Wiring must be installed in a conduit on the exterior of the pole that is susceptible to damage from the elements, accidents and vandalism. We do not consider wood to be suitable for modern sport fields. The Little League Baseball Association standards do not allow wood poles. Residents may consider wood poles to be aesthetically objectionable.

COST ISSUES

Costs are typically a major concern for owners, including capital costs, maintenance costs and operating costs. The graphic in *Figure 2-8 – Basic Components of a Sports Lighting System* shows the basic elements of a sports lighting installation. Each major component is discussed with respect to costs.

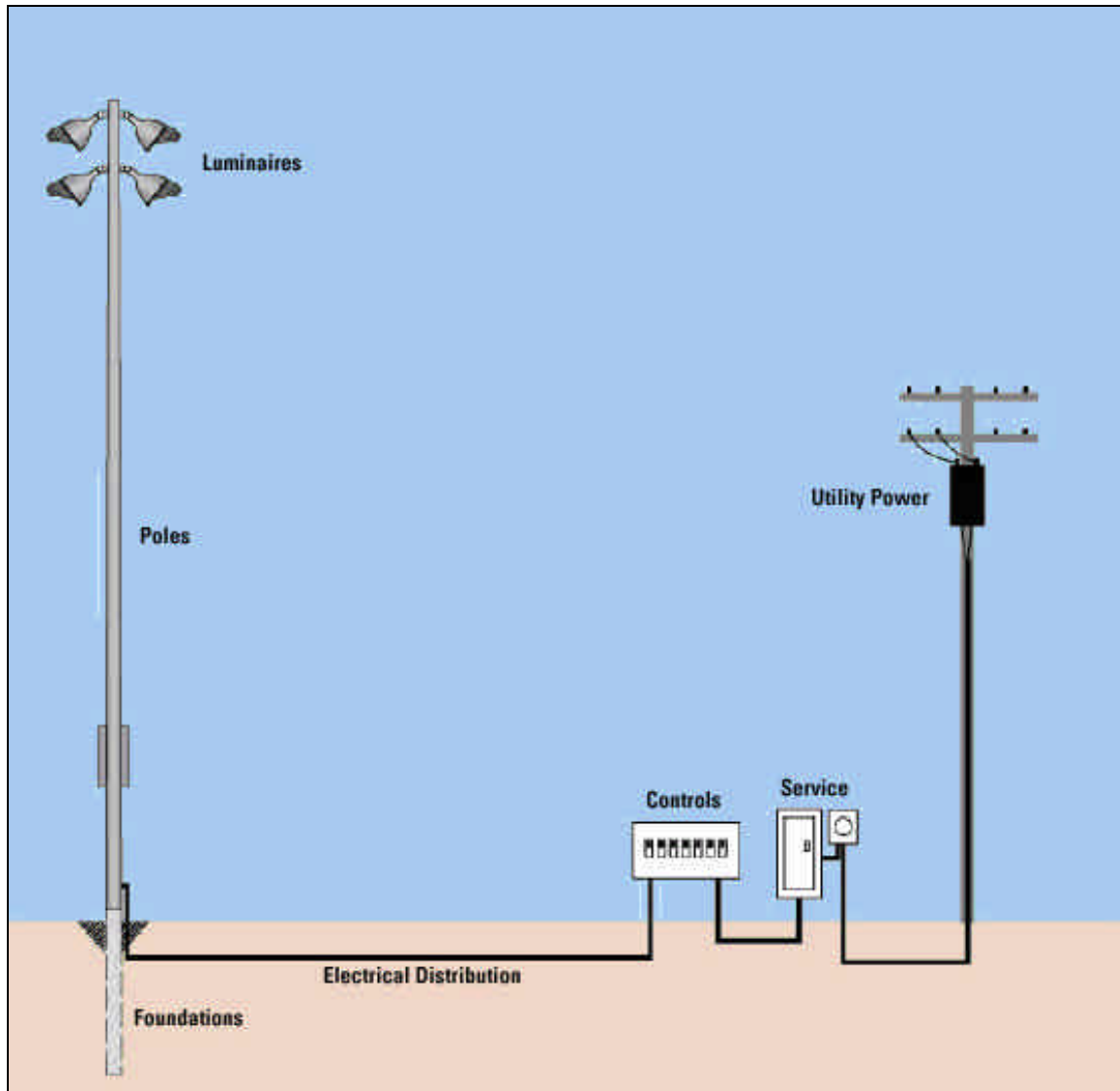


Figure 2-8 – Basic Components of a Sports Lighting System

Utility Power and Power Transformer

The local utility company will typically supply power and a step-down transformer for each facility. The size of the transformer is determined by the load the facility will require, and is calculated by the sports lighting consultant. Costs for the supply of power vary depending on the availability (is the required power available near the site?), the size of the power supply, and the way a local utility structures rates. Some power companies charge for the cost of a new service up front, while others amortize the cost of improvements over time by including a portion of the cost in the monthly bill or rate charged. Utility power supply can be a significant portion of the cost of a sports lighting installation and may vary from 2.0 percent to over 10.0 percent or more of the capital costs.

Electrical Service

Includes the power revenue meter box and all required panelboards, switchboards, breakers and other components designed to provide overcurrent protection for the electrical system. The electrical service may be installed in a free-standing cabinet or in a building, and is designed by the sports lighting consultant. The cost of the service will be 10.0 percent or more.

Lighting Controls

Includes key switches, push-button switches, automatic timers or remotely controllable devices to switch the lights on and off. This is a very important part of the system and will be designed by the sports lighting consultant to provide the convenience and control desired. Typical remote-addressable control systems can add between \$5000 and \$10,000 or more to the cost of the sports lighting, and may require a monthly or annual fee for communications and data service.

Underground Power Distribution

Includes conduit, pull boxes and wiring for the sports lighting system, typically buried underground. Because costs for distributing power at lower voltages increase due to larger wire size, it is recommended that 277/480-volt power be used for sports lighting. Underground power distribution costs can escalate if trenching requirements are unusual or if obstructions are present (such as retaining walls, streets, paved areas, etc.). Common trenching can minimize costs. Typically underground distribution costs are 30.0 percent or more of the total cost of sports lighting.

Foundations

Concrete foundations are required to support the poles and luminaires. Because soils conditions vary from site to site, foundations must be designed for each project. The design of a sports lighting foundation requires both geotechnical and structural design. If the foundations are not properly designed, poles may lean, affecting the aiming of the luminaires. This is known as a service failure. In extreme cases, inappropriate foundations may result in pole collapse. Because foundations are expensive, limiting the number and size of foundations is a key concern in controlling overall costs.

Poles

Typically constructed from steel or concrete. Modern systems often include pre-engineered poles. If the pole is not pre-engineered, structural calculations will be required to select the proper pole for a project. A pole and foundation can cost \$10,000 or more, so limiting the number of poles is a key to reducing costs for a sports lighting installation. We do not recommend wood poles for sports lighting because they twist and bend as they age, negatively affecting the aiming of the luminaires (service failure). Wood poles also rot from the inside out, and may be unsafe after only a few years of use.

Luminaires

These are the components most people think of when envisioning a sports lighting system. Modern sports lighting luminaires are complex, and designed to carefully control light output. Luminaires consist of engineered lamps and reflectors, and may include shielding, louvers and visors to control the light beam. Many luminaires today are designed as a package system, complete with crossarms (or attached to pole-top assemblies) and devices to allow pre-aiming in the factory. The result is an integrated package that accurately delivers the light to the proper point on the field. The number of luminaires required is connected to the efficiency of the luminaire to distribute light (the more efficient the luminaire, the fewer fixtures needed), and the wattage of the luminaire. Most sports lighting luminaires are available in either 1000-watt or 1500-watt versions. Using 1500-watt luminaires reduces capital costs by 1/3, and also affects the size of poles due to the reduced wind load.

CONTROL SYSTEMS FOR SPORTS LIGHTING

Lighting control systems for sports lighting installations should provide owners with features that provide desired flexibility and control given current or projected management of fields. For instance, a facility that is always staffed by the owner can have very basic off/on controls, while a field that is not staffed may benefit from remote control so the lights can be programmed and operated from off site.

Options for controls include switching, time clocks, interface with sprinkler controllers and packaged systems. All systems must be integrated with the lighting electrical system by the engineer.

- **Switching** – Simple switching without additional control may be appropriate for some situations where a facility is constantly manned. Typically key switches or push buttons are provided in a secure location and are used to switch the lights on and off as needed. Security lights may be controlled with a photo cell in these instances.
- **Time Clocks** – Time clocks are suitable for the control of sports lighting system when the field schedule is known in advance and is predictable. The disadvantage to time clocks is that they require on site programming, programming may be somewhat complicated, and there is no provision for remote administration if a game is cancelled. Time clock control can be integrated with user interaction (such as key switches or pushbutton) for energizing and turning off the lights. Multiple channels are required if more than one field is controlled, and if the owner wishes to control security lights or other features (such as restroom locks) via the time clock.
- **Sprinkler Controllers** – Turf fields often use sprinkler controllers that also can be used to control the lights. Sprinkler controllers include models that require on-site programming or control via radio signals. If simple control is all that is needed and a sprinkler controller is already in place, the use of this technology may be appropriate.
- **Packaged Controls** – Packaged sports lighting control systems include sophisticated control units that allow remote administration to control the lighting. Engineering requirements relate only to integrating the control system into the electrical system, not developing ladder logic or other systems. In addition to control features, the packages may track field use, energy consumption, and other useful data.

Two packaged systems are currently available that are specifically designed for sports lighting. These include Musco's Control Link System and the ARC-10 system from SkyLogix. These two systems use different methods to provide similar results. The SkyLogix system, in addition to being marketed as SkyLogix, is also packaged with Qualite sports lighting systems under the brand name ReQuest. Musco provides its control system only in conjunction with its sports lighting system. The Skylogix system may be used with any sports lighting product. Both systems require monthly fees.

- Musco's Control Link system is an engineered control system that uses satellite signals to control the lights. The owner has the flexibility to use internet-based scheduling from a secure web-browser page, or contact a person employed at a staffed control center (manned 24-hours per day, 365 days per year). The control center serves as an intermediate step between the user and the physical control of the lights. If the user wishes to control the state of the lights, he or she communicates that desire to the control center via email, web browser command or telephone communication. Control signals from the staffed control center are then sent to the field control units via communications signal in real time to control the target devices. A toll free 800 number with passcode access allows owners to direct control center staff to initiate real time control with a slight delay (minutes). Through use of unique passcodes, an owner can provide nearly real time control of the lights to a variety of individuals with various levels of access.

The system also provides remote monitoring of equipment by two-way communications, providing the

control center with information on electrical and lamp failures. In the case of a controls failure, the control center can be contacted by telephone for limited telephone support. Typical installation of the Control Link system also allows for on-site override of the system in case of a failure through the use of hand/off/auto switches at the point of service.

The web-based browser interface allows owners to secure reports on field usage, power consumed, and other details. This information can be helpful in analyzing field usage and apportioning costs for the use of the lights.

- Skylogix's ARC-10TM (ReQuest) is a wireless, control system that uses radio pager signals to control the lights. On/off signals are sent directly to the remote control units from a computer or touch tone telephone. On/off commands can also be entered from an onsite key pad using a personal identification number (PIN) code. The system can be operated with from its own desktop application running on a personal computer, and also interfaces with various field scheduling software packages which can send on/off signals. Usage reports can be printed from the PC-based control system. The reports can be helpful in analyzing field usage and apportioning cost for the use of the lights.

In the case of a controls failure, Skylogix can be contacted during normal business hours for assistance. Typical installation of the Skylogix system also allows for on-site override of the system in case of a failure through the use of hand/off/auto switches at the point of service.

STANDARDS AND DOCUMENTS RELATED TO SPORTS LIGHTING

Sports field lighting systems are designed and evaluated based on existing standards that are readily available and generally accepted. Because the study of light and its application is constantly changing with advances in science and the study of human behavior, the various standards are periodically updated in view of continuing discovery.

NORTH AMERICAN SPORTS LIGHTING STANDARDS

The most commonly followed standards in the United States lighting industry are those of the IESNA. IESNA is an organization that was founded in 1906 to advance knowledge and disseminate information for the improvement of the lighted environment for the benefit of society. IESNA produces numerous publications, a small number of which are aimed at sports lighting installations. Lighting design professionals and suppliers typically use IESNA documents in their work. Individual professionals and others interested in lighting may also be members of the organization. Other standards typically follow or correspond to IESNA recommendations.

Sports Lighting and Recreational Lighting (IESNA RP-6)

This document was originally produced in 1968 (RP-6-68) and was last revised in 1988 (RP-6-88) and in 2001 (RP-6-01). It is intended to provide a “recommended practice” for the illumination of indoor and outdoor sports facilities for safe play. This document is the most comprehensive publication of sports lighting recommendations available from IESNA. Though last revised in 2001, it is relatively current with the sports field lighting practices of today. It is currently being revised and will be re-issued by IESNA in 2006.

The IESNA system uses a Class of Play system to establish the basis for variations in the lighting level, and also provides a table that addresses each sport with respect to the Class of Play to establish minimum recommended values for both illumination and uniformity. *Table 3-1 – IESNA Class of Play System* defined the class of play system, while *Table 3-2 – IESNA Lighting Levels and Max to Min Uniformities* is included below with respect to typical recreational ball sports addressed in this report.

Table 1 – Class of Play and Facilities				
Facility	Class			
	I	II	III	IV
International	X			
National	X			
Professional	X			
College	X	X		
Semi-professional	X	X		
Sports clubs	X	X		
Amateur leagues		X	X	
High schools		X	X	
Training facilities			X	X
Elementary facilities			X	X
Recreational facilities				X
Social events				X
Class I – Facilities with spectator capacity of 5000 to 200,000				
Class II – Facilities for spectators of 5000 or less				
Class III – No special provisions for spectators				
Class IV – Social and recreational, i.e., noncompetitive				

Table 3-1 – IESNA Class of Play System

Light Trespass: Research, Result and Recommendations (IESNA TM-11)

TM-11 was published by IESNA in 2000. It is a technical memorandum providing a brief description of findings and references related to a 1998 research project for measuring, determining and identifying light trespass. The majority of TM-11 is based on a research paper produced for the Lighting Research Office, Electric Power Research Institute (EPRI). The author of this paper was Dr. Ian Lewin, PhD, of Lighting Sciences, Scottsdale, Arizona. Dr. Lewin is considered a leading lighting expert in North America. TM-11 is currently the best available document for the measurement of spill light.

TM-11 establishes four “environmental zones” based on a subjective assessment of existing levels of ambient light. These zones are based upon and generally follow the International Commission on Illumination (CIE) standards. The CIE is based in Europe. Recently the term environmental zone has been modified by most professional organizations and is now referred to as lighting environmental zones (LEZs). LEZs are discussed in a previous section.

Recommendations in TM-11 provide for maximum levels of light trespass for each LEZ, as previously discussed. The document establishes maximum light trespass levels for “pre-curfew” and “post-curfew” periods. “Curfew” refers to time established by a community when non-essential lighting may be reduced or switched off. Post-curfew restrictions do not apply to sports field lighting installations because they typically address situations where lights remain energized throughout the night. It is assumed that sports lighting for recreational play will not extend into post-curfew hours.

Much of the research in TM-11 is based on the study of luminance, even though the recommended light trespass levels are expressed in illuminance. This highlights a continuing debate in the lighting community as to the best method of light trespass analysis. Some experts in the sports lighting industry agree that a luminance-based standard would provide a much better analysis of glare than the illuminance method. It is commonly accepted, however, that an illuminance-based method is the best currently available and a usable approach to establishing glare control standards.

Dr. Lewin supports the illuminance method for calculating and measuring glare and spill light and has commented in a private conversations with Don McLean of DMD that, in his opinion, an illuminance-based method deals better with disability glare, while a luminance-based method deals better with discomfort glare. Many of the glare issues faced in the design of a sports field lighting installation involve mitigating discomfort glare for players.

In conversations with Dr. Lewin, the issue of illuminance versus luminance measurements of spill light was discussed. Dr. Lewin commented that in his opinion illuminance is the only quantity of measurement that takes into account intensity and distance and that is why TM-11 is based on illuminance. He also confirmed our findings that source intensity is virtually impossible to field measure with commonly available current technology.

Dr. Lewin noted that the City of Scottsdale, AZ, under his guidance, developed a lighting ordinance for sports lighting installations based on TM-11. They standardized on an LEZ 3 pre-curfew environmental zone with spill light levels from lighting installations not exceeding 0.8 fc. The TM-11 document defines the ambient light level by environmental zone. It does not specifically state the actual ambient light levels.

The scope of TM-11 is incomplete and additional research will be undertaken in the near future. At this point the document establishes recommended maximum spill light levels consistent with available research.

National Little League Association Standards and Safety Audit

The National Little League Baseball Association published specific lighting standards which are documented in a 1996 Little League Lighting Standards and Safety Audit. This standalone document covers all aspects of electrical system and lighting design and testing for Little League installations. The document is divided into two parts – required minimum standards, and optional, but desirable features. Required maintained average horizontal illumination levels and uniformities are provided, which correspond with IESNA RP-6 recommendations for a Class III level of play.

Other notable issues in this standard include the following.

- A quasi-uniformity gradient system is discussed that limits the rate of change between 10-foot grid points to 10 percent.
- Wood poles are not allowed because of the potential for twisting with age, a condition that negatively affects illuminance levels and uniformity on the field.
- Fixture aiming is not allowed over 65 and 69 degrees from vertical, depending on the position of the pole.
- Remote ballasts and capacitors are required to be housed in separate enclosures.
- When poles are located inside field boundary, padding is required.
- Little League standards do not deal with light trespass issues of spill light, glare, and sky glow.

OTHER STANDARDS APPLICABLE TO SPORTS LIGHTING

Underwriters Laboratory

Underwriters Laboratories Inc. (UL) is an independent, not-for-profit product safety testing and certification organization that was founded in 1894.

Typically electrical equipment manufactured and used in the United States is required to be UL listed and as such bear a UL certification label. Sports lighting manufacturers may bundle their products (such as luminaires) with other components (poles, ballast boxes, etc.). Each electrical component should bear a UL label. Manufacturers who provide complete sports lighting systems may have the entire system, in addition to individual components, certified by UL.

National Electrical Manufacturers Association (NEMA)

NEMA, created in 1926 by the merger of the Electric Power Club and the Associated Manufacturers of Electrical Supplies, provides a forum for the standardization of electrical equipment, enabling consumers to select from a range of safe, effective, and compatible electrical products.

NEMA standards are commonly used throughout North America. In the lighting industry, NEMA standards are typically used for luminaires, electrical boxes and electrical panels. With respect to sports lighting, NEMA standards typically apply to luminaire beam spreads, and to ingress protection ratings for cabinets and electrical panels.

International Building Code (IBC)

The IBC set standards and requirements for structural and fire- and life-safety provisions covering seismic, wind, accessibility, egress, occupancy, roofs, and others. With respect to sports lighting installations, the IBC requirements apply to pole structures and foundations, including structural strength and wind loading.

COMMENTARY ON THE REVIEW OF STANDARDS

When developing sports lighting standards a number of conflicting interests must be balanced. These conflicting interests include the following key groups.

- Local residents who are concerned with issues of light trespass. Standards and processes for evaluating spill light and glare should be established.
- User groups and players who desire high levels of light and appropriate uniformities to ensure safe play. On-field lighting performance standards appropriate for the sport and the class of play should be developed and field should be tested for compliance.
- Municipal officials and staff with limited capital and operating budgets along with a community mandate to provide high quality programs for a growing population of sports enthusiasts. Designs should focus on minimizing capital, operating, and maintenance costs.

In addition to these interests, a strong consideration must be to set standards achievable with available and emerging technology. If standards are set so high that they cannot be achieved, only frustration will result.

Similarity in Sports Lighting Standards

RP-6 recommendations for on field lighting are similar to and approximate those of the National Little League Association and other published standards in North America. The Little League document is a performance standard and does not restrict the choice of manufacturers. The Little League document has “Required Minimum Standards” that are primarily performance based and have “Disable Criteria” which is not mandatory. There are a number of suppliers that can meet these standards.

We find the RP-6 to be the most comprehensive sports lighting document available in North America. Although admittedly not the final word, it provides readily accepted and achievable standards that address issues of safe play and light trespass.

RECOMMENDATIONS

1. We recommend that the IESNA Class of Play System and corresponding lighting levels be adopted for design standards. Where different user groups will use the same field yet fall into different levels of play (e.g., recreational softball vs. Little League baseball) we recommend consideration of dimming systems to reduce lighting levels to minimum recommended levels as appropriate.
2. We further recommend that the spill light standards be addressed through the application of TM-11 and RP-33 with respect to maximum allowable levels of spill light.
3. We recommend that glare be controlled by limiting the amount of candela from the worst-case aimed fixture to 12,000 cd (calculated). The City of Seattle has established this standard for their parks, and we find this level of glare to be achievable and to produce a positive result when compared with designs that have no glare criteria.
4. We recommend that sky glow be controlled by using fixtures with external shielding and proper mounting heights to limit the amount of light cast into the air by the fixtures to a maximum of 5.0 percent of candela from total lamp lumens at 90 degrees from nadir. Refer to *Figure 2-3 IESNA Cut-off Classifications*.
5. As the lighting industry is experiencing a great deal of technological advancement, it is recommended that the standards and process for designing sports lighting in Fairfax County be reviewed on a regular basis. A five to seven year interval is suggested.

INTERNATIONAL DARK-SKY ASSOCIATION REVIEW

The International Dark-Sky Association (IDA) is a non-profit organization established in 1988. The IDA's goals are to stop the adverse environmental impact on dark skies by building awareness of the problem of light pollution, propagating solutions and educating the public about the value and effectiveness of quality nighttime lighting.

The IDA has produced a very comprehensive "*Outdoor Lighting Code Handbook*." The IDA describe their Handbook in the following excerpt.

This Handbook discusses issues relative to outdoor lighting codes, their effectiveness, implementation, and enforcement. A "pattern code" is included, both as a starting point for communities who wish to consider a lighting code and as a way of discussing many of the issues that arise. This pattern code is not to be considered as a model code to be implemented as-is. Each community will have different needs and different priorities. The Handbook is written mainly for communities in the USA, but many of the issues are the same for other applications, such as state codes or codes outside the USA. Appendices include forms useful for administering a code, descriptions of several recently adopted lighting codes, and other information. The Handbook is intended to be a dynamic document, and it will be revised regularly as new information is developed in the effective application of lighting codes, and the science and art of outdoor lighting.

IESNA and IDA standards deal more with spill light than glare in their discussions of light trespass. The IDA also focuses on sky glow, as the interests of astronomers are the basis for the organization's existence.

The focus on spill light vs. glare may be the result of the ease of measuring spill light levels, and the absence of such measurement and analysis methods relating to glare. Our experience, however, indicates that off site glare is typically as important an issue as the level of spill light.

Glare is a very complex issue to analyze and mitigate due to its subjective nature. Dating back to original IESNA documents produced in 1904, glare has been noted as a major issue. Although a definitive North American standard relating to glare levels does not exist, we have developed a process to establish allowable glare levels and a method to calculate glare levels in the design stage. This method, which is explained later in this section, has in our experience been effective in controlling objectionable glare.

We find the IDA recommendation of spill light not exceeding 0.1 fc at the off-site residential property line adjacent to the field to be a nearly impossible recommendation to achieve. To further explain the significance of the 0.1 fc light trespass requirement we have illustrated a typical urban street lighting installation as a comparison. Typically street lights are often positioned in relative close proximity to residential properties (within 10 ft or so). *Figure 4-1 – Light Trespass from Urban Street Light* shows the vertical illumination level at approximately 6 feet above grade to be approximately 1.3 fc. This level is 13 times greater than the 0.1 fc level required by the IDA. This standard is impractical to achieve.

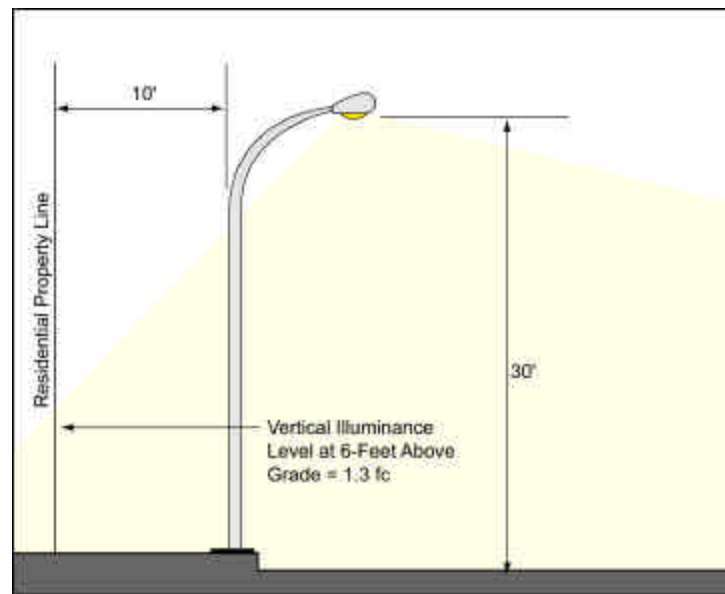


Figure 4-1 – Light Trespass from Urban Street Light

The IESNA recommendations in RP-33 and TM-11 are more rational and achievable than those proposed by the IDA, recommending spill light levels that vary from 0.1 to 1.5 fc depending upon conditions.

While one of the IDA goals is to reduce sky glow, the sports field lighting designer must be careful to maintain some level of illumination above the sports field lighting fixtures to maintain a safe level of play by allowing players to track the movement of the ball when it goes above the lights, a condition that occurs in baseball and less often in softball. For this reason, we do not recommend the use of full cutoff luminaires for baseball and softball installations. One must remember the IDA's agenda is to reduce light trespass, including sky glow, not set standards for safe play. Owners must be concerned with establishing and meeting standards that reduce liability exposure by providing for safe play.

The IDA prefers the use of fully shielded fixtures for sports field lighting. The IDA defines a fully shielded fixture as one with no light emitted above horizontal. These criteria can be achieved with a horizontally mounted flat glass system and a variety of aimable fixtures with external visors. We have analyzed aimable fixtures with external visors, and confirmed that if they are aimed at 32 degrees below horizontal there is virtually no light emitted above horizontal. This is shown in *Section 2, Figure 2-4 – Cutoff Comparison of Sports Lighting Fixture with Downward Aiming*.

It is important to note that no matter how well a fixture controls the light above horizontal, there will always be reflected light from the field surface. Surface reflectance becomes a factor when assessing sky glow. All weather sand-type fields typically have a high surface reflectance (10.0 to 15.0 percent or more) and may contribute significantly to sky glow. Grass and synthetic turf fields with rubber infill absorb more light resulting in lower levels of sky glow from reflected light (about 3.0 to 5.0 percent based on DMD existence readings taken during performance measurements).

Not every type of sports field lighting fixture deals with light trespass in an equal fashion. Manufacturers typically produce a range of products to satisfy a segmented market and deal with a variety of specified performance criteria, and performance may vary from manufacturer to manufacturer. *Figure 4-2 – Fixture Comparison* below illustrates the differences in off-site glare encountered on the basis of a digital photograph. All of the fixtures in the photo are from the same manufacturer. Each of the fixtures was certified by a qualified lighting designer from DMD to have been mounted at the same height (the tall fixture in the foreground is an existing street lamp, not a sports field lighting fixture), identically aimed, and having the same beam spread, voltage supplied, and lamp wattage. As one

can see, the ability of the fixtures to control glare varies between the fixtures even when they are all sourced from the same manufacturer.



Figure 4-2 – Fixture Comparison

REVIEW OF FAIRFAX COUNTY ZONING ORDINANCE

We have reviewed the Fairfax County Lighting Ordinance as it relates to sports lighting. The ordinance *Section 14-904 Outdoor Recreation/Sports Facility Lighting Requirements* specifically deals with sports lighting.

The ordinance is somewhat general with respect to sports lighting, with the primary prescriptive requirements limited to submittals, maintained lighting levels (illuminance) for various sports and the use of “full cut-off or directionally shielded lighting fixtures, aimed toward the playing field/court and shielded in directions away from the playing field/court so as to minimize glare and light trespass onto adjacent properties.”

The athletic field lighting equipment recommended in this study fully complies with the requirements contained in the Fairfax County Zoning Ordinance.

COMPARISON OF CURRENTLY AVAILABLE SPORTS LIGHTING PRODUCTS

The goal of this study was to objectively compare currently available sports lighting systems to allow the owner to understand the differences in features, construction and value between the various products available. As a result, a comparison matrix is provided in this section, as well as a life-cycle cost analysis in its own section.

Currently Available Products

There are two types of lighting systems currently available for sports field lighting. The most common type uses aimable type luminaries based on a high intensity discharge (HID) lamps that distribute light using parabolic reflectors. This type of fixture is shown in *Figure 6-1 – Typical Aimable Sports Lighting Fixture* (Qualite fixture shown). All available products of this type use metal halide (MH) lamps, and nearly all fixtures currently available use external shields to assist with light control.



Figure 6-1 – Typical Aimable Sports Lighting Fixture

Currently available aimable sports field lighting solutions include systems from General Electric, Hubbell, Musco, Qualite and USL. In general, these systems offer spill and glare control systems and are specifically designed for sports fields. These manufacturers offer componentized-style systems. A “componentized system” includes galvanized steel poles, foundations, pre-aimed fixtures, internal wiring, disconnect switches, ballasts and capacitors (typically in a separate, remote-mounted enclosure). These lighting systems can be supplied with either 1000-watt or 1500-watt metal halide light sources (although some manufacturers also offer a 2000-watt fixture option).

The other type of product uses fixed down lights with HID sources similar to parking lot lighting, and is pictured in *Figure 6-2 Typical Fixed Downlight-Type Sports Fixture* (Soft Lighting pictured; the photo shows fixtures being assembled in the foreground; installed fixtures are visible in the background).



Figure 6-2 – Typical Fixed Downlight-Type Sports Fixture

Fixed downlights marketed as sports lighting are a unique solution from Puget Sound-based Soft Lighting. The firm uses multi-purpose down-light style luminaires equipped with 1000-watt light sources. The luminaires are a “flat glass” style fixture with forward-throw optics. This type of full-cutoff flat glass luminaires are commonly used for roadway and parking lot lighting. The Soft Lighting solution uses a mix of MH and high-pressure sodium (HPS) light sources. Characteristically, Soft Lighting installations require additional poles over the aimable type sports light systems.

Recently another supplier, Zone Lighting, has entered the market with a flat-glass fixture similar to Soft Lighting. Zone Lighting, however, was not considered in this study because the product lacked a history of deployment and had no agent in the Virginia area. At the time of our inquiry, no full-sized baseball/softball or soccer facilities had been constructed using Zone Lighting’s luminaire, although the product had been successfully deployed for tennis courts and a skate park.

Lighting suppliers such as Cooper, Holophane, Lithonia, Widelite and others also offer fixtures that may be used for sports lighting. Because these fixtures are designed to be multipurpose, lighting designers have found that the optics do not have the same spill light and glare control optics and overall efficiencies and benefits of the specifically designed package sports lighting system. As a result we have not considered these fixtures for this evaluation. Based on our experience, we believe specifically designed sports lighting systems have clear advantages. These systems reduce labor and contractor risk over systems where poles, fixtures, and other components all come from various sources. Over the last 10 years we have found that specifying componentized systems has dramatically reduced contractor change orders, reduced installation time, and has improved the overall quality of lighting installations.

PRODUCTS EVALUATED

For the purpose of this study, SWSG and DMD solicited participation from major sports lighting suppliers doing business in the Fairfax County area, either by contacting the manufacturer or by contacting local lighting products agents.

Initial interest in the study was received from the following five suppliers.

1. Hubbell Lighting
2. Musco Lighting
3. Qualite
4. Soft Lighting
5. Universal Sports Lighting (USL)

A local supplier representing General Electric (GE) was contacted, but no interest was shown.

Initially, four of the manufacturers of aimable systems showed interest in the study, including Hubbell, Musco, Qualite and USL. USL, following a request for information, dropped out of the study. Soft Lighting, the supplier of the flat-glass system also expressed interest and participated.

FIXTURES COMPARED

A general description of each system evaluated in the comparison matrix is provided below. Manufacturer provided material is provided in the Volume 2 of this study.

Hubbell Sportsliter

The Hubbell Sportsliter is an aimable system using a parabolic reflector, internal louvers and an external shield that significantly reduces obtrusive light. The fixture is shown in *Figure 6-3 – Hubbell Sportsliter*. The light source is MH and fixtures are preaimed at the factory. Lamps are oriented in the horizontal position, eliminating the need to derate the lamps for tilt factor. The system features remote ballasts. Galvanized steel poles are mounted to a cast-in-place foundation secured with anchor bolts and a base plate. An optional remote control system is available based on the Skylogix system. An optional extended warranty covering a relamping and all parts and labor for a 10 year period is available. The system is provided as a componentized system, allowing rapid construction and minimizing field adjustments for “fit and finish.”



Figure 6-3 – Hubbell Sportsliter

Musco Light Structure Green

Musco's Light Structure Green is a new product that represents the next generation in sports lighting. The fixture is shown in *Figure 6-4 – Musco Light Structure Green*. The system is based on parabolic reflectors with inserts, a lamp with the arc tube oriented horizontally in the axial position, and external visors. The system features remote ballasts with a new "smart" ballast technology that maintains lighting levels at a relatively constant level throughout the life of the lamp. Galvanized steel poles are slip-fit over a precast spun concrete base, which is supplied by Musco. The capital cost for the system includes their extended warranty for 10 years, as well as their Control Link remote control unit. Innovations in luminaire design have resulted in a reduction in the number of fixtures needed, as well as improved obtrusive light control. Fixtures are factory preaimed. The system is provided as a componentized system, allowing rapid construction and minimizing field adjustments for "fit and finish."

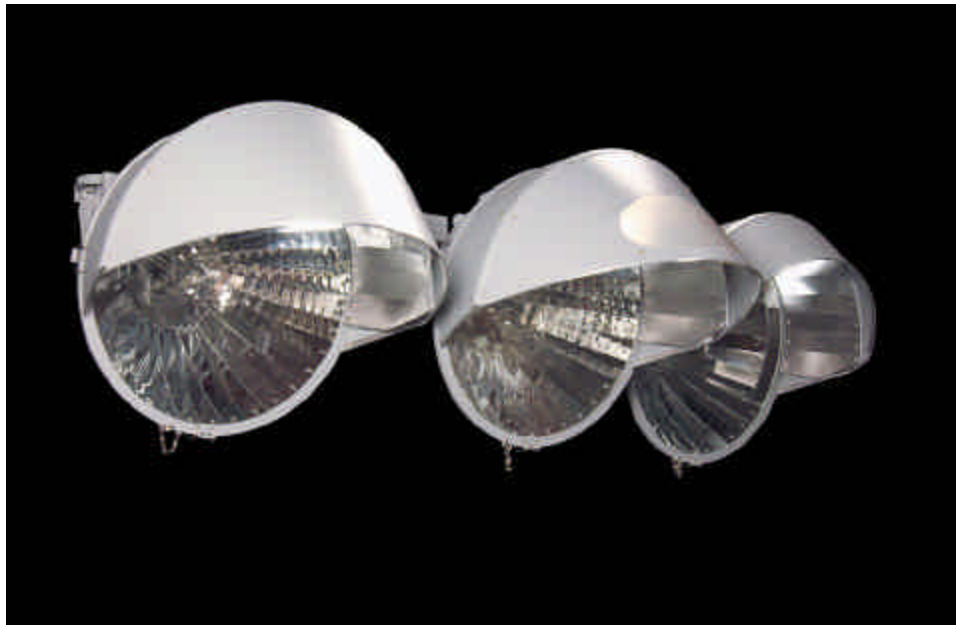


Figure 6-4 – Musco Light Structure Green

Qualite Pro Series

The Qualite Pro Series is an aimable system using spun parabolic reflectors with axially-mounted lamps and an optional external glare shield to limit obtrusive light. The system features remote ballasts and preaimed fixtures. An optional remote control system called ReQuest is available. The control system is not proprietary to Qualite, but is provided by Skylogix, an Arizona-based controls firm, and simply re-branded by Qualite. An optional extended warranty covering a relamping and 10 years of parts and labor is also available. Galvanized steel poles are mounted to a cast-in-place foundation secured with anchor bolts and a base plate. The system includes a diagnostic unit that plugs into a connector at the ballast box for diagnostics in the field. The system is provided as a componentized system, allowing rapid construction and minimizing field adjustments for "fit and finish."



Figure 6-5 – Qualite Pro Series

Qualite GoldSeries

The Qualite Gold Series is a an aimable system using spun parabolic reflectors with axially-mounted lamps, as well as an external glare shield with painted and polished louvers to limit obtrusive light. *Figure 6-6 – Qualite Gold Series* shows the fixture. The surface of the reflector has also been modified, and is not smooth. The system features remote ballasts and preaimed fixtures. An optional remote control system called ReQuest is available. The control system is not proprietary to Qualite, but is provided by Skylogix, an Arizona-based controls firm, and simply re-branded by Qualite. An optional extended warranty covering a relamping and 10 years of parts and labor is also available. Galvanized steel poles are mounted to a cast-in-place foundation secured with anchor bolts and a base plate. The system includes a diagnostic unit that plugs into a connector at the ballast box for diagnostics in the field. The system is provided as a componentized system, allowing rapid construction and minimizing field adjustments for “fit and finish.”



Figure 6-6 – Qualite Gold Series

Qualite International Series

The Qualite International Series is an aimable system using spun parabolic reflectors with horizontally -mounted double-ended lamps and an external glare shield to limit obtrusive light. The fixture is shown in *Figure 6-7 – Qualite International Series*. The use of a horizontally-mounted lamp eliminates the need to derate lamp performance for tilt factor. The surface of the reflector is smooth. The system features remote ballasts and preaimed fixtures. An optional remote control system called ReQuest is available. The control system is not proprietary to Qualite, but is provided by Skylogix, an Arizona-based controls firm, and simply re-branded by Qualite. An optional extended warranty covering a relamping and 10 years of parts and labor is also available. Galvanized steel poles are mounted to a cast-in-place foundation secured with anchor bolts and a base plate. The system includes a diagnostic unit that plugs into a connector at the ballast box for diagnostics in the field. The system is provided as a componentized system, allowing rapid construction and minimizing field adjustments for “fit and finish.”



Figure 6-7 – Qualite International Series

Soft Lighting Systems

The Soft Lighting Systems uses fixed downlights, and is a unique system in many respects. The fixtures are shown in *Figure 6-8 Soft Lighting*. Soft Lighting does not provide their product as a componentized system, although Soft Lighting supplies poles and other components to provide a complete system, excluding wiring. Foundation designs, as well, are left to the owner. Components (luminaire mounting brackets, luminaires, etc.) are assembled and wired in the field. The multi-purpose down-light style luminaires are equipped with 1000-watt light sources (all other systems evaluated use 1500-watt fixtures). The luminaires are a “flat glass” style fixture with forward-throw optics. The Soft Lighting solution uses a mix of MH and high-pressure sodium (HPS) light sources (all other systems evaluated use only MH sources). Due to the lower wattage and the light distribution pattern of the luminaires, Soft Lighting installations require additional poles over the aimable type sports light systems.



Figure 6-8 – Soft Lighting

The main feature of the Soft Lighting solution is full cut-off optics that minimizes sky glow and may reduce glare in some situations. In reducing direct light out of the fixture above horizontal, the full cut-off optics may make it more difficult to see the ball when it goes above the lights. In our opinion, this makes a full cut-off system less desirable for baseball and softball. The full cut-off optics also may have limitations when it comes to illuminating a field to competitive levels (IESNA Class II and III of greater than 50 fc).

The Soft Lighting system uses a mixture of approximately 60 percent MH and 40 percent HPS light sources. This mixture of metal halide and high-pressure sodium is unique to Soft Lighting. Metal Halide is a blue-white light source whereas high pressure sodium is a yellow-orange light (monochromatic) source. A concern with mixing high-pressure sodium and metal halide is the rate at which the lamps depreciate. The lamp life of the two sources is quite different. The owner is cautioned that over time the high pressure sodium will overpower the metal halide source if the metal halide is not replaced prior to failure. Typically a 1000-watt HPS lamp has twice the rated life (12,000 hours for metal halide versus 24,000 for high pressure sodium). This concern could be minimized with group re-lamping at a preset time period where the lamps are not allowed to operate until they burn-out.

HPS lamps also have a much lower Color Rendering Index (CRI) than metal halide; however, it has a higher efficacy (lumens per watt) and longer lamp life as noted above. In general, CRI is an indication of a lamp's ability to show individual colors relative to a standard. CRI is a scale of 1 to 100 with 100 being perfect color rendition and 1 being no color rendition. As an example a typical HPS has a CRI around 20 whereas as a metal halide lamp is around 65.

For sports such as baseball and softball with high ball speeds, an all metal halide installation is recommended. For sports with slower ball speeds, such as soccer, the choice of a MH with HPS mix is an option.

CONSULTANT TEAM REQUEST FOR INFORMATION

To provide an objective comparison of available products, certain information regarding each product and its performance was required. DMD & Associates developed a request for information that included 19 pieces of information, ranging from product information to lighting designs for typical fields to cost estimates for equipment costs. The request was provided in a checklist format, with generic specifications for the typical design fields. A copy of the request for information is provided in the Appendix.

Following the request for information, submittal packages were received from Hubbell Lighting, Musco Lighting, Qualite and Soft Lighting. USL, who had initially shown interest, provided only limited information and as a result is not included in the analysis. Basic information from each of the participating manufacturers with respect to their sports lighting products is included with this study.

It is important to note that nearly every manufacturer has a series of fixtures that are marketed, from basic flood lights adapted for sports lighting use, to purpose-built assemblies with engineered optics with various levels of glare and spill light control. It is critical for sports lighting designers to recognize the differences provided by various optical systems and to ensure that sufficient performance standards are established to ensure the owner will receive the desired performance when two or more fixtures are approved for the purpose of competitive bidding. The request for information clearly stated to “use your best spill and glare control.” Initially, Qualite submitted a single fixture for consideration, their “Pro” series luminaire. Upon further consideration, however, they elected to also provide information on a more high-end product, their “International” series luminaire as well.

COMPARISON APPROACH

The consultant team elected to provide two separate comparisons – a feature/performance comparison using a weighted scoring system, and a life-cycle cost comparison. The scored feature/performance comparison is presented in a matrix spreadsheet. The life-cycle cost comparison is presented in its own section as a spreadsheet with narrative.

Because the Soft Lighting product is unique, scoring for this product was modified as indicated on the scored comparison. Features that do not apply to Soft Lighting were noted, and the score and rankings were adjusted accordingly.

COMPARISON MATRIX

The comparison matrix was developed to be as objective as possible, with evaluation based on a “meets” or “does not meet” for each criterion in a comparison matrix. If it could not be determined if the system or component under consideration met or did not meet the criterion from the information provided, the consultant team sought additional information from the supplier. If, after the additional information is received, it still could not be determined if the system or component meets or does not meet the criterion, this is noted in the narrative comments.

NARRATIVE COMMENTS FOR MATRIX ITEMS EVALUATED

Narrative comments have been provided, as needed, as noted in the matrix. In the comments section, which follows the matrix, we noted if an item that “does not meet” is critical to owner with respect to quality, constructability, performance or maintenance. This will allow the reader to discriminate between product features that have objective value as opposed to those that merely differentiate one product from another or reflect a manufacturer’s willingness to provide information that is proprietary. We have also noted where manufacturers provided information that deviated from the information requested. This is especially important with respect to calculations, where manufacturers may choose to calculate expected results using variables somewhat different than those requested.

DESCRIPTION OF PERFORMANCE AND FEATURES COMPARISON CRITERIA

The following criteria were used to compare the systems with respect to features and performance. The numbering system indicated is duplicated on the comparison spreadsheet matrix.

The consultant team developed the comparison spreadsheet. The weighting for each item evaluated was developed by the consultant team and provided to the owner for review. Where needed, to meet the desire and needs of the owner, weighting for individual items were modified in consultation with FCPA project planning and maintenance staff.

1 - Compliance with Codes and Standards

1.1 UL Listing for Components. The consultant team examined submittals to determine if the components are UL listed. The evaluation for this criterion will be Meets or Does Not Meet.

1.2 UL Listing for System. The consultant team examined submittals to determine if UL Listing has been secured for the configuration of the components in a system.

1.3 Complies with Local Codes. The consultant team examined submittals to determine if the sports lighting package, or any part of the package, does not meet local codes as defined by the request for information.

1.4 No Poles in IESNA Glare Zones. The consultant team examined designs to determine if the manufacturer's design requires poles in IESNA glare zones. Poles in the glare zones can be a safety concern for players.

1.5 Meets Wind Load Requirements. The consultant team examined submittals to determine if poles and foundations are designed for local wind load requirements.

2 - Lighting Performance

2.1 Meets On-Field Lighting Minimum Performance Requirements. For the design field, the consultant team specified the required lighting performance on the field per IESNA criteria. The consultant team examined each manufacturer's design for compliance with average maintained illuminance and max-to-min uniformity.

2.2 Meets Maximum Spill Light Performance Requirements. For each design field, the consultant team specified the maximum allowable spill light per IESNA Publication TM-11 at an arbitrary boundary (150-feet from the field edge) representing a typical project site. For objective comparison, a point was chosen at the middle of each field for meter orientation. A drawing was provided to assist the manufacturer. Based on the design submitted, the consultant determined if the product met the criteria.

2.3 No Direct Uplight from Fixtures on a Plane 10-feet above the Upper Luminaire Mounting Height. For the design field, the consultant team asked the manufacturer to provide an inverted illuminance measurement scan above the mounting height of the upper luminaire. This scan provides a means to compare the amount of light cast into the night sky by the fixtures. Scores were based meeting "no uplight" from the fixtures.

2.4 Meets Glare Control Performance Requirements. For the design field, The consultant team evaluated the maximum candlepower from a typical fixture at an arbitrary property line (200 feet from the edge of the field). The maximum allowable candlepower was 12,000 cd. The consultant team has found that meeting this requirement results in a reduction in complaints regarding offsite glare from neighbors. In

the commentary section, the performance of the individual manufacturers is compared to show the differences in glare control.

2.5 Luminaires Tested for Photometric Performance by Independent Laboratory. The consultant team will determine if the required photometric data provided by the luminaire manufacturer has been provided by an independent testing laboratory. Independent testing of luminaires gives designers confidence that the luminaire will deliver the promised performance.

2.6 Photometric Data Available to Electrical Engineer. The consultant team determined if the manufacturer will release IESNA photometric files and data to the engineer (subject to non-disclosure and confidentiality agreement) for use in analysis. Some manufacturers are unwilling to release photometric data as they consider this information to be proprietary.

2.7 No Narrow Beam (NEMA 1 and 2) Fixtures. The consultant team determined if the design submitted uses narrow beam fixtures (NEMA 1 and 2 beam types). Narrow beam fixtures may cause “hot spots” on the field, an undesirable result.

2.8 Lighting Performance Guaranteed by Manufacturer. The consultant team determined if the manufacturer provides a guarantee regarding the performance of the lighting system to meet the specified illumination levels and uniformities if installed as designed. The consultant team also provided an opinion with regard to the presence of conditions that may render the guarantee difficult to enforce, such as unreasonable conditions.

2.9 Spill Light Levels Guaranteed by Manufacturer. The consultant team determined if the manufacturer guarantees compliance with spill light levels predicted in their design. This issue can be important if conditional use permits require meeting a maximum allowable level.

3 - Luminaires

3.1 Luminaire Constructed from Corrosion Resistant Materials. The consultant team examined information to determine if the materials used in the construction of the luminaire are corrosion-resistant, including hardware. Corrosion-resistant materials include hot-dipped galvanized steel, powder-coated or anodized aluminum. Non-current carrying fasteners, hinges and latches should be stainless steel and coated to prevent galvanic interaction.

3.2 Glare Control Devices (Shields, Louvers, Visors). The consultant team evaluated if the luminaires utilize glare control devices to control light distribution.

3.3 Removable Impact Resistant Lens. The consultant team determined if the lens is removable without special tools for relamping and cleaning of the luminaire and constructed from impact and thermal resistant materials (glass).

3.4 Secure Lens Attachment. The consultant team determined if the lens attachment includes a hinged cable, chain or other device to prevent it from falling during removal for relamping.

3.5 Silicone Gasket (or Equal). The consultant team will determine if the optical assembly is sealed with a gasket constructed from silicone or other similar material to prevent moisture and dirt intrusion which can affect performance.

4 - Luminaire Mounting and Aiming

4.1 Factory Aiming. The consultant team determined if the luminaires are factory aimed, that is, that each luminaire mounting assembly is mounted to the crossarm or pole top assembly in the factory so that it does not need to be manually aimed in the field. Merely supplying aiming coordinates for field aiming via protractor is not considered factory aiming.

4.2 Aiming Recapture Method. The consultant team determined if the luminaire includes a feature to recapture the factory aiming position following relamping.

4.3 Aiming Field Adjustments Possible. The consultant team determined if the individual luminaires are field adjustable if fine tuning is needed to meet lighting performance specifications.

4.4 Luminaire Attachment and Assembly Resistant to Wind Damage and Misalignment. The consultant team determined if the luminaire and luminaire mounting has been tested and guaranteed to resist damage and misalignment from wind gusts of up to 125 mph.

4.5 Lamp May Be Rotated to Allow Cleaning and Lamp Replacement from Behind Pole. The consultant team determined if the luminaire assembly is able to be rotated to allow service, cleaning and relamping from a lift platform positioned behind the pole. This feature is important because it allows service without driving heavy service vehicles onto field surfaces which may not be designed for the weight of a typical lift (30,000 to 40,000 pounds).

5 - Lamp

5.1 Appropriate Lamp Specified (MH). The consultant team determined if the lamp specified is appropriate to the design in terms of wattage, maximum lumens, lumen maintenance and mortality rate, and that the lamp is metal halide (MH) which is preferred for its higher color rendering index (CRI).

5.2 Lamp Tilt Factor Provided in LLF. The consultant team determined if the lamp tilt factor is included in the Light Loss Factor (LLF) and appears to be appropriate. HID lamps must be derated for lumen output when the arc tube is tilted beyond their design position (typically horizontal). If the appropriate tilt factor is not included, calculations may indicate better lighting performance than can be expected in the field.

5.3 Arc Tube Shielded. The consultant team determined if the manufacturer has provided physical shielding of the arc tube to reduce glare.

6 - Ballast and Ballast Enclosure

6.1 Ballast Matches Lamp. The consultant team determined if the ballast matches the ANSI Lamp Type. The type of ballast is noted in the comments.

6.2 Remote Ballast Mounted at Ladder Height. The consultant team determined if the ballast is remotely mounted from the lamp to provide for easy servicing at a height reachable by ladder. Remote ballasts were noted as preferred in the request for information.

6.3 Individual Ballast for Each Luminaire. The consultant team determined if a ballast is provided for each luminaire.

6.4 Ballast Enclosure Constructed from Aluminum for Improved Heat Transfer and Maintenance. The consultant team determined if the ballast enclosure is constructed from aluminum for improved heat transfer and improved resistance to corrosion, which is a maintenance issue. Most ballast failures result

from excessive heat build up, and aluminum ballast enclosures resist corrosion when compared to similar enclosures constructed from steel.

6.5 Electrical Disconnect in Ballast Enclosure. The consultant team determined if the ballast enclosure contained an electrical disconnect to allow for easy servicing at the pole.

6.6 Ballast Enclosure NEMA 3R or Better Rating. The consultant team will determined if the ballast enclosure has a minimum NEMA rating of 3R. This rating assures the owner that the ballast enclosure will perform well in outdoor conditions with respect to water intrusion.

6.7 Ballast Enclosure Includes Locking Feature. The consultant team determined if the ballast enclosure is lockable to prevent unauthorized entry (by vandals or curious citizens). This is a safety issue.

6.8 Wiring in Ballast Enclosure Factory Installed and Tested. The consultant team determined if the ballast enclosure is factory wired and electrically tested.

6.9 Ballast Assembly Properly Labeled and Includes Schematic. The consultant team determined if the circuits and components in the ballast enclosure are labeled for easy identification, and if a wiring schematic is provided.

6.10 Spare Fuses Included in Ballast Enclosure. The consultant team determined if a location for spare fuses is provided in the ballast enclosure for ease of maintenance in case of a fuse failure.

6.11 Wireway into Pole is Watertight. The consultant team determined if the wireway into the pole from the ballast enclosure is water tight.

7 - Wiring

7.1 Factory Built Wiring Harness. The consultant team determined if the manufacturer provides a factory-built wiring harness.

7.2 Factory Tested Wiring Harness. The consultant team determined if the manufacturer provides factory testing of wiring harnesses prior to shipping.

7.3 Wiring Harness Includes Abrasion-Resistant Features. The consultant team determined if the wiring harness supplied includes features to resist abrasion.

7.4 Wiring Harness Attachment Included in Poles. The consultant team determined if the manufacturer includes a means to attach the wiring harness to the pole to aid in rapid construction.

7.5 Wiring Harness Includes Labeling. The consultant team determined if the manufacturer provides labeling of wiring harnesses. This prevents improper connections by the contractor.

7.6 Wiring Harness Features Plug-Type Connectors. The consultant team determined if the wiring harness connections are via plug-type connections for ease of construction/service.

7.7 Lightning Protection Provided. The consultant team determined if the lightning protection system provided meets NFPA 780.

7.8 Grounding Lugs Provided. The consultant team determined if grounding lugs are provided by the manufacturer in the pole and ballast enclosure.

8 - Pole Top Assembly or Crossarms

8.1 Pole Assembly or Crossarms Constructed from Corrosion Resistant Materials. The consultant team determined if the materials used in the construction of the pole top assembly or crossarms are corrosion-resistant, including hardware. Corrosion-resistant materials will typically be hot-dipped galvanized steel.

8.2 Pole Top Assembly or Crossarm Welded Construction and Factory Mounted. The consultant team determined if the pole top assembly or crossarms assembly is welded construction, or bolted. Welding is considered superior. Mounting at the factory in a controlled environment is also considered superior.

8.3 Pole Top Assembly or Crossarm Can Be Used as Raceway for Internal Wiring. The consultant team determined if the wiring for the luminaires is contained within the pole top assembly or crossarms.

9 - Poles

9.1 Poles Constructed from Corrosion Resistant Materials. The consultant team determined if the materials used in the construction of the pole are corrosion-resistant, including hardware. Corrosion-resistant materials will typically be hot-dipped galvanized steel or concrete.

9.2 Poles Meet Structural Strength Requirements. The consultant team determined if the poles meet structural requirements for the weight and wind load.

9.3 Pole Interior Can Be Used as Raceway for Wiring. The consultant team determined if the electrical wiring contained within the pole.

9.4 Custom Brackets Available. The consultant team determined if the manufacturer offers custom brackets on poles for adding security lights, speakers, cameras, etc.

9.5 Pole Cap Provided. The consultant team determined if the pole includes a cap to resist water intrusion to the pole interior. Meet.

10 - Foundation

10.1 Concrete Foundation with Engineer Certification. The consultant team determined if the foundation design is concrete, and if the supplier provides an Engineer's certification for the design. The owner does not allow direct-bury steel poles.

11 - Service and Warranty

11.1 Local Warranty and Maintenance Service Available. The consultant team determined if local service is available from the manufacturer.

11.2 Standard Warranty Provided. The consultant team evaluated each submittal to determine if a warranty is provided.

11.3 Evaluate Standard Warranty and Rank. The consultant team evaluated the terms of each manufacturer's warranty and ranked it, giving maximum points to the best warranty.

11.4 Evaluate Extended Warranty and Rank. The consultant team requested pricing for the owner's extended warranty and evaluated each. The extended warranties were ranked, giving maximum points to the best extended warranty.

12 - Controls

12.1 Remote Lighting Controls Available from Manufacturer as Part of Packaged System. The consultant team determined if the manufacturer provides a remote control system for operating the sports lights. Providing these controls as part of the packaged system eliminates integration headaches and surprises. The consultant team will note if the control system is proprietary, or provided by a third party.

12.2 System Allows Owner to Switch Lights via Telephone 24-hours per Day. The consultant team determined if the lights can be switched via telephone at any time.

12.3 System Allows Owner to Switch Lights via Telephone 24-hours per Day. The consultant team determined if the remote control package provides field usage reports which can be helpful in field programming operations.

12.4 System Provides Remote Diagnostics. The consultant team determined if the remote controls system can provide remote diagnostics of the field lighting system.

COMPARISON MATRIX

The Comparison Matrix is provided on the following pages. Following the matrix, commentary is provided, where necessary, for each criterion.

Sports Lighting Study



				Type of System						See Narrative Comments (Note Number Provided)
				Aimable					Fixed	
Item No.	Code**	Category Item Evaluated	Weight*	Hubble Sportsliter Score (1 or 0) x Weight	Musco Light Structure Green Score (1 or 0) x Weight	Qualite Pro Series Score (1 or 0) x Weight	Qualite Gold Series Score (1 or 0) x Weight	Qualite International Series Score (1 or 0) x Weight	Soft Lighting** Score (1 or 0) x Weight	
1		Compliance with Codes and Standards								
1.1	Q	UL Listing for Components	3	3	3	3	3	3	3	
1.2	Q	UL Listing for System	3	3	3	3	3	3	0	1.2
1.3	C	Complies with Local Codes (Score 1 for Yes, 0 for No. A "0" indicates product will be rejected for further review)	1	1	1	1	1	1	1	
1.4	P	No Poles in IESNA Glare Zones	3	3	3	3	3	3	1.5	1.4
1.5	C	Meets Wind Load Requirements	3	3	3	3	3	3	0	1.5
Total Score This Category				13	13	13	13	13	5.5	
Rank (This Category)				1	1	1	1	1	2	
2		Lighting Performance								
2.1	P	Meets On-Field Lighting Performance Minimum Requirements (IESNA RP-6)	3	3	3	3	3	3	1.5	2.1
2.2	P	Meets Maximum Spill Light Performance Requirements	3	3	3	0	3	3	3	
2.3	P	No Direct Uplight from Fixtures on a Plane 10 feet above the Upper Luminaire Mounting Height	1	0	1	1	1	1	1	2.3
2.4	P	Meets Glare Control Performance Requirements	3	2	3	3	3	2	3	
2.5	P	Luminaires Tested for Photometric Performance by Independent Laboratory	2	0	0	2	2	2	0	2.5
2.6	P	Photometric Data Available to Electrical Engineer	2	2	0	2	2	2	0	2.6
2.7	P	No Narrow Beam (NEMA 1 and 2) Fixtures	1	0	1	1	1	1	NA	2.7
2.8	QCP	On-Field Lighting Performance Guaranteed by Manufacturer (Must be Deemed to Enforceable)	3	3	3	3	3	3	0	2.8
2.9	QCP	Spill Light Levels Guaranteed by Manufacturer (Must be Deemed to Enforceable)	3	3	3	3	3	3	0	2.9
Total Score This Category				21	16	17	18	21	20	8.5
Rank (This Category)				2	2	1	1	1	3	
3		Luminaires								
3.1	Q	Luminaire Constructed from Corrosion Resistant Materials (Note Materials in Comments)	3	3	3	3	3	3	3	3.1
3.2	P	Glare Control Devices (Shields, Louvers, Visors)	2	2	2	2	2	2	NA	3.2
3.3	M	Removable Impact Resistant Lens	2	2	2	2	2	2	2	
3.4	M	Secure Lens Attachment	2	2	2	2	2	2	2	
3.5	M	Silicone Gasket (or Equal)	2	2	2	2	2	2	2	
Total Score This Category				11	11	11	11	11	9	
Rank (This Category)				1	1	1	1	1	1	
4		Luminaire Mounting and Aiming								
4.1	CP	Factory Aiming	3	3	3	3	3	3	NA	4.1
4.2	M	Aiming Recapture Method	3	3	3	3	3	3	NA	4.2
4.3	M	Aiming Field Adjustments Possible	1	1	1	1	1	1	0	4.3
4.4	M, Q	Luminaire Attachment and Assembly Resistant to Wind Damage and Misalignment	3	3	3	3	3	3	3	
4.5	M	Luminaires May Be Rotated to Allow Cleaning and Lamp Replacement from Behind Pole	3	3	3	3	3	3	0	4.5
Total Score This Category				13	13	13	13	13	3	
Rank (This Category)				1	1	1	1	1	2	
5		Lamp								
5.1	P	Appropriate Lamp Specified (MH)	2	2	2	2	2	2	2	5.1
5.2	P	Lamp Tilt Factor Provided in LLF Calculation	2	2	2	0	0	2	2	5.2
5.3	P	Arc Tube Shielded	2	0	0	0	0	0	0	
Total Score This Category				6	4	4	2	4	4	
Rank (This Category)				1	1	2	2	1	1	

Sports Lighting Study



Item No.	Code**	Category Item Evaluated	Weight*	Aimable					Fixed	See Narrative Comments (Note Number Provided)
				Hubble Sportsliter Score (1 or 0) x Weight	Musco Light Structure Green Score (1 or 0) x Weight	Qualite Pro Series Score (1 or 0) x Weight	Qualite Gold Series Score (1 or 0) x Weight	Qualite International Series Score (1 or 0) x Weight	Soft Lighting*** Score (1 or 0) x Weight	
6		Ballast and Ballast Enclosure								
6.1	Q	Ballast Matches Lamp (Note Ballast Type in Comments)	2	2	2	2	2	2	2	
6.2	M	Remote Ballast Mounted at Ladder Height	3	3	3	3	3	3	0	
6.3	MPQ	Individual Ballast Provided for Each Luminaire	3	3	3	3	3	3	3	
6.4	PM	Ballast Enclosure Constructed from Aluminum for Improved Heat Transfer and Maintenance	3	3	3	0	0	0	NA	6.4
6.5	M	Electrical Disconnect in Ballast Enclosure	3	3	3	0	0	0	NA	6.5
6.6	M	Ballast Enclosure Rated NEMA 3R or Better	3	3	3	3	3	3	3	
6.7	M	Ballast Enclosure Includes Locking Feature	3	3	3	3	3	3	NA	
6.8	Q	Wiring in Ballast Enclosure Factory Installed and Tested	2	2	2	2	2	2	0	
6.9	Q	Ballast Assembly Labeled and Includes Schematic	2	2	2	2	2	2	0	
6.10	M	Spare Fuses Included in Ballast Enclosure	2	0	2	0	0	0	0	
6.11	M	Wireway into Pole is Watertight	1	1	1	1	1	1	NA	
Total Score This Category				27	25	27	19	19	8	
Rank (This Category)				2	1	3	3	3	4	
7		Wiring								
7.1	QMC	Factory Built Wiring Harness	2	2	2	2	2	2	0	
7.2	QC	Factory Tested Wiring Harness	2	2	2	2	2	2	0	
7.3	QM	Wiring Harness Includes Abrasion-Resistant Features	2	2	2	2	2	2	0	
7.4	Q	Wiring Harness Attachment Provided in Poles	1	1	1	1	1	1	1	
7.5	CM	Wiring Harnesses Include Labeling for Proper Connections	1	1	1	0	0	0	0	
7.6	CM	Wiring Harness Features Plug-Type Connectors	1	1	1	1	1	1	0	
7.7	Q	Lightning Protection Provided	1	1	1	1	1	1	1	
7.8	QC	Grounding Lugs Provided	2	2	2	2	2	2	2	
Total Score This Category				12	12	12	11	11	4	
Rank (This Category)				1	1	2	2	2	3	
8		Pole Top Assembly or Crossarms								
8.1	QM	Pole Top Assembly or Crossarms Constructed from Corrosion Resistant Material	3	3	3	3	3	3	3	
8.2	CQM	Pole Top Assembly or Crossarms Welded Construction and Factory Mounted	3	0	3	0	0	0	3	8.2
8.3	Q	Pole Top Assembly or Crossarm Meets Structural Strength Requirements	2	2	2	2	2	2	0	8.3
8.4	QM	Pole Top Assembly or Crossarm Can Be Used as Raceway for Wiring	3	3	3	3	3	3	3	
Total Score This Category				11	8	11	8	8	9	
Rank (This Category)				3	1	3	3	3	2	
9		Poles								
9.1	QM	Poles Constructed from Corrosion Resistant Materials (Note material in Comments)	3	3	3	3	3	3	3	
9.2	Q	Poles Meet Structural Strength Requirements	2	2	2	2	2	2	0	
9.3	QCM	Pole Interior Can Be Used as Raceway for Wiring	3	3	3	3	3	3	3	
9.4	C	Custom Brackets Available for Speakers, Cameras or Security Luminaires	1	1	1	1	1	1	1	
9.5	QM	Pole Cap Provided	2	2	2	2	2	2	2	
Total Score This Category				11	11	11	11	11	9	
Rank (This Category)				1	1	1	1	1	2	
10		Foundations								
10.1	QC	Concrete Foundation with Engineer Certification	3	3	3	3	3	3	0	10.1
Total Score This Section				3	3	3	3	3	0	
Rank (This Category)				1	1	1	1	1	2	

Sports Lighting Study



Item No.	Code**	Category Item Evaluated	Weight*	Aimable					Fixed	See Narrative Comments (Note Number Provided)
				Hubble Sportsliter Score (1 or 0) x Weight	Musco Light Structure Green Score (1 or 0) x Weight	Qualite Pro Series Score (1 or 0) x Weight	Qualite Gold Series Score (1 or 0) x Weight	Qualite International Series Score (1 or 0) x Weight	Soft Lighting*** Score (1 or 0) x Weight	
11		Service and Warranty								
11.1	M	Local Warranty and Maintenance Service Available	3	3	3	3	3	3	0	11.1
11.2	M	Standard Warranty Provided	1	1	1	1	1	1	1	
11.3	MP	Evaluate Standard Warranty (Rank and make Comments). Evaluate what each manufacturer provides and rank with maximum points to the best warranty, and fewer points to lesser warranties. A maximum of 3 points will be awarded.	3	2	3	2	2	2	1	11.3
11.4	PM	Evaluate Extended Warranty (Rank and make Comments)	3	2	3	1	1	1	0	11.4
Total Score This Section				10	8	10	7	7	2	
Rank (This Category)				2	1	2	2	2	3	
12		Controls								
12.1	PM	Remote Lighting Controls Available from Manufacturer as Part of Packaged System	3	3	3	3	3	3	0	
12.2	PM	System Allows Owner to Switch lights via Telephone 24-hours per day	3	3	3	3	3	3	0	
12.3	PM	System Provides Field Usage Reports	3	3	3	3	3	3	0	
12.4	PM	System Provides Remote Diagnostics (see commentary for details)	2	0	2	2	2	2	0	12.4
Total Score This Section				11	9	11	11	11	0	
Rank (This Category)				2	1	2				
Overall Score				149	133	143	127	130	131	62
Overall Ranking (features and construction)				2	1	3	4	4	5	
Percentage of Maximum Score				89%	96%	85%	87%	88%	48%	

* Weight is assigned to indicate relative value of importance for the criterion.

**Codes column relates the item evaluated to one or more of the following areas:

C = Constructability

P = Performance

M = Maintenance

Q = Quality

Consultant may use overall scores for each code area for secondary ranking criteria.

***Due to the unique nature of the Soft Lighting Product, some items evaluated do not apply. Category Rankings, Overall Rankings and Percentage of Total Score have been adjusted. Items not evaluated are noted as "NA".

NARRATIVE COMMENTARY ON COMPARISON MATRIX CRITERION

Note: Numbering in this section corresponds to the matrix Item Number.

2.1 Meets On-Field Lighting Performance Minimum Requirements (IESNA RP-6). The criteria established for the design fields used in the comparisons is based on calculation requirements established in the request for information provided to the manufacturers. Musco Lighting and Qualite elected not to use one or more calculation element as specified.

Musco Lighting used a lower “average lumen” value based on their new “smart” ballast which limits lumen output to near maintained levels using a four-step dimming system. This system results in energy efficiency over systems that do not use the “smart” ballast technology. We accept this deviation in the calculation based on Musco’s guarantee to provide the maintained levels throughout the useful life of the lamp.

Qualite did not include the proper tilt factor in its calculation for the Pro fixture, but used a 1.0 factor (no tilt). Because the lamp is axially mounted in the fixture and vertical aiming is required, we do not believe that this tilt factor is correct. We contacted Qualite and spoke to Vice President Rich Kohl. Qualite provided information noting that the lamp used is rated at 162,000 initial lumens. Their design, however, uses the initial lumen value of 155,000. This difference is supposed to offset the lack of a tilt factor in the calculation, which Mr. Kohl indicated is plus or minus 15 degrees. We estimate, based on information provided by the lamp manufacturer that the de-rating factor for an average 15-degree tilt is approximately 3.0 percent. Mr. Kohl was asked to provide a calculation using the 155,000 lumen lamp and using the proper average tilt factor. In the absence of meeting this request, Mr. Kohl was asked to supply lumen maintenance and mortality curves for the 162,000 lumen lamp (neither item was supplied).

1.4 No Poles in IESNA Glare Zones. Soft Lighting’s baseball/softball design requires poles in the IESNA Glare Zones. Their soccer field design, although it uses more poles, locates all poles in areas approved by the IESNA. 1.5 points (half of the 3.0 points available) were subtracted from their score to indicate the deficiency in the baseball design.

1.5 Meets Wind Load Requirements. Soft Lighting’s material did not indicate that wind load requirements were met. Their standard specifications note that testing, at the owner’s expense, is available from the pole supplier. Therefore, their score for this item is zero.

2.1 Meets On-Field Lighting Performance Minimum Requirements (IESNA RP-6). 1.5 points were subtracted from Soft Lighting’s score for this item as the baseball/softball design submitted does not meet uniformity requirements.

2.3 No Direct Uplight from Fixtures on a Plane Above the Upper Luminaire Mounting Height. The Sportsliter Fixture from Hubbell showed minimal uplight on the requested plane for baseball/softball and for soccer. This is a minor issue.

2.4 Meets Glare Control Performance Requirements. For comparison we used a NEMA 4H x 4W fixture and the aiming diagram to calculate candlepower at an angle intersecting a defined boundary (assumed to be 200 feet from the field edge). If the calculation showed 12,000 candlepower or less at this line, it met the criteria. Qualite submitted numerous photometric test reports none of which were a NEMA 4 x 4. We selected the test reports for a NEMA 4H x 3V which were used for their lighting designs.

2.5 Luminaires Tested for Performance by and Independent Testing Laboratory. Both Hubbell and Musco have their own testing laboratories, which follow voluntary guidelines for testing. Qualite’s luminaires were tested by an independent laboratory.

2.6 Photometric Data Available to the Electrical Engineer. Musco declined to release photometric files to the engineer, noting that they consider individual luminaire performance and the associated data files to be proprietary

information. They did offer to provide the results of any analysis we desired for the study. Soft Lighting did not provide the requested photometric files.

2.7. No Narrow Beam Fixtures. Hubbell used NEMA 2 beam spreads in their design. DMD has a concern with the use of narrow beam spread fixtures because their use can result in “hot spots” on the field that do not show up in calculation grids typically used to evaluate performance. The owner is cautioned that a tighter grid (say 10 feet) should be used to evaluate designs with narrow beam fixtures for the hot spot phenomena.

2.8 On-Field Lighting Performance Guaranteed by the Manufacturer (Must Be Deemed to Be Enforceable).

Current industry practice is for the manufacturer to assume responsibility for illumination designs for their products, and to guarantee on-field performance. Taking responsibility for the final illumination design allows manufacturers to fine tune the number of fixtures needed, and be competitive on a cost basis as the per fixture cost can be \$1500 or more. Past experience has shown that enforcement of performance guarantees can be troublesome if the field does not meet minimum performance requirements. Adjustments can range from re-aiming to adding fixtures, requiring additional structural support and electrical infrastructure. These adjustments are expensive, and are typically resisted by manufacturers who may qualify their guarantee with requirements for expensive and time consuming owner-supplied testing and verification of field conditions. The owner is cautioned to carefully examine guarantees each time a project is bid, and determine if the guarantee is enforceable.

Soft Lighting does not guarantee system performance and was scored zero for this item.

2.9 Spill Light Levels Guaranteed by the Manufacturer. This comment echoes the concern stated in 2.8. If use of the fields is contingent upon maximum spill light levels, such as may be the case if a conditional use permit is required, the owner is cautioned that adjustments may be required following installation. Typically these adjustments are re-aiming, but can include the addition of visors or other spill light control devices. If additional devices such as larger visors are required, poles may be loaded beyond their design limits.

Soft Lighting does not guarantee system performance and was scored zero for this item.

3.1 Luminaire Constructed from Corrosion Resistant Materials. All luminaires evaluated use aluminum reflectors and other corrosion resistant materials.

3.2 Glare Control Devices (Shields, Louvers, Visors). Soft Lighting fixtures, based on their IESNA full-cutoff classification, do not require glare control devices to limit offsite glare. Installation, however, must be with the fixture oriented parallel to the field surface to take advantage of the cutoff classification performance.

4.1 Factory Aiming. Soft Lighting fixtures cannot be aimed in a manner similar to an aimable fixture.

4.2 Aiming Recapture Method. Soft Lighting fixtures, because they are fixed to the pole without adjustment options, cannot be recaptured to an aiming orientation. The aiming orientation is fixed at the time of installation. This item was deemed Not Applicable to Soft Lighting.

4.3 Aiming Field Adjustments Possible. See commentary on 4.1 and 4.2 above. Soft Lighting fixtures cannot be adjusted. This item was scored, however, because field conditions may require adjustment to meet performance criteria following installation.

4.5 Luminaire May Be Rotated to Allow Cleaning and Lamp Replacement from Behind Pole. This is an important issue for maintenance, particularly if the field uses a synthetic field surface. The typical weight of an 80-foot lift is 30,000 pounds, therefore driving on field surfaces may cause damage. As poles are typically located close to the field, it may not be possible to locate the lift for easy access from the front of the pole. The typical issue with regard to fixture design is the ability to rotate the luminaire to the back of the pole, which requires adequate horizontal and vertical spacing between fixtures. Also, the aiming position must be recaptured (see 4.2).

5.1 Appropriate Lamp Specified (MH). Soft Lighting, by design, uses a mix of MH and HPS lamps.

5.2 Lamp Tilt Factor Included in LLF Calculations. See commentary under 2.1. Qualite uses a 1.0 tilt factor (no tilt) even though the arc tubes in their fixtures are tilted up to 15 degrees. For Qualite International series the lamp is horizontally oriented and no tilt factor is required. Hubbell uses a horizontally-oriented lamp (no tilt) and Musco uses a lamp and positioning that results in no tilt. Soft Lighting lamps are oriented horizontally and require no tilt factor.

6.4 Ballast Enclosure Constructed from Aluminum for Improved Heat Transfer and Maintenance. Soft Lighting ballast is integral with the lamp, and as a result, this item was deemed not applicable.

6.5 Electrical Disconnect in Ballast Enclosure. Qualite's Rick Kohl indicated that this feature was being added to their system. Confirmation was requested via a cut sheet and/or shop drawing but was not received.

11.1 Local Warranty and Service Available. Manufacturers may use local contractors to supply this service. Soft Lighting's warranty notes payment for service will be compensated to the owner, indicating no local service is available.

11.3 Evaluate Standard Warranty. Warranties were ranked based on judgment. Soft Lighting's warranty is very limited with many conditions. Products manufactured by Soft Lighting have a two year warranty, but components such as ballasts and lamps are noted to be covered by their respective manufacturers. Ballast replacement under warranty, for instance, is afforded a \$15.00 labor charge without credit for rental of equipment or travel time. Lamps are excluded from the parts and labor portion of the warranty. As the cost to rent a lift to access the ballasts and lamps (located at the pole top) will be significant, we believe that this warranty assigns significant risk to the owner.

11.4 Evaluate Extended Warranty. Warranties were ranked based on judgment. Soft Lighting does not offer an extended warranty.

12.4 System Provides Remote Diagnostics. The Musco Control Link system provides two-way communications with remote diagnostics. Qualite and Hubbell use a re-branded Skylogix system, which according to the Skylogix, has the capability for remote diagnostics. We are unfamiliar with the remote diagnostics provided by Skylogix, but based on a discussion with the manufacturer are satisfied that the features are similar to Musco's Control Link.

LIFE CYCLE COST ANALYSIS

Life cycle costs for sports field lighting systems include three major components.

1. **Capital Costs** – Capital costs include the cost of equipment and installation. Installation costs are assumed to be nearly equal for all systems, although an additional amount has been included for the Soft Lighting System based on the larger number of poles.

For this study, based on the owner's desire, we have included the cost of a 10-year extended warranty, and the cost of an optional remote control system, as provided by the manufacturer. Soft Lighting does not include a remote control system, and as a result this cost is not included in their price. We estimate that adding a Skylogix system to the Soft Lighting system will add \$6500 to their cost. Soft Lighting does not provide an extended warranty. To compensate, an additional relamping has been included in maintenance costs (below).

2. **Maintenance Costs** – Maintenance costs are assumed to include relamping and cleaning of the luminaires on a schedule based on design criteria and estimated lamp life. Incidental costs associated with failed components are not included. An additional relamping and cleaning has been added to the Soft Lighting estimate to compensate for the lack of an extended warranty.
3. **Operations Costs** – Operations costs are assumed to include energy costs. No allowance has been made for labor for personnel manning the fields. Energy costs per kilowatt hour are calculated based on 2005 rates as provided by the owner. Demand charges are not included.

A 30-year period was assumed for the life expectancy of the sports lighting system. Based on our experience and the observed practice of typical owners, we believe that this is a reasonable life expectancy.

The attached spreadsheets provide the life cycle cost analyses. Costs are based on design fields established in the request for information provided to suppliers.

A numeric ranking, based on Total Life Cycle Cost is included on the spreadsheets .

The lowest cost system (for both baseball/softball and soccer), Musco Light Structure Green, gains most of its total life cycle cost advantage based on savings in operations and maintenance. These savings include a longer maintenance interval, and lower energy costs.

Life Cycle Cost Analysis for Sports Lighting Systems

Design Field -- Soccer	Hubbell Sportsliter	Musco Light Structure Green	Qualite Pro Series	Qualite Gold Series	Qualite International Series	Soft Lighting
Capital Cost						
Sports Lighting Equipment	\$ 34,625.00	\$ 51,000.00	\$ 36,100.00	\$ 37,800.00	\$ 49,600.00	\$ 113,000.00
Extended Warranty (10 years Maintenance)	\$ 3,456.00	included	\$ 4,800.00	\$ 4,800.00	\$ 6,800.00	Not Available
Optional Remote Control	\$ 5,000.00	included	\$ 4,900.00	\$ 4,900.00	\$ 4,900.00	Not Available
Estimated Installation Costs	\$60,000.00	\$60,000.00	\$60,000.00	\$ 60,000.00	\$ 60,000.00	\$ 70,000.00
Estimated Total Capital Cost	\$ 103,081.00	\$ 111,000.00	\$ 105,800.00	\$ 107,500.00	\$ 121,300.00	\$ 183,000.00
Maintenance Costs (30 years)						
Relamp Frequency (Based on Supplier Data and 600 hours per year usage)	5 Years	8.3 Years	5 Years	5 Years	5 Years	6 Years
Number of Relamps Required Beyond the Extended Warranty (from year 10 to year 30)*	4	3	4	4	4	5
Estimated Relamp and Cleaning Costs Each Occurrence (2005 Dollars)	\$ 3,452.00	\$ 3,860.00	\$ 3,328.00	\$ 3,328.00	\$ 5,428.00	\$ 3,660.00
Estimated Total Maintenance Costs (30 Years)	\$ 13,808.00	\$ 11,580.00	\$ 13,312.00	\$ 13,312.00	\$ 21,712.00	\$ 27,140.00
Operations Costs (30 Years)						
No. of Fixtures	32	20	28	28	28	48
Consumption per Fixture kW	1.6	1.6	1.6	1.6	1.6	1.175
Hours of Use Per Year	600	600	600	600	600	600
No. of Years	30	30	30	30	30	30
Cost per Kilowatt (2005 Dollars)	0.06	0.06	0.06	0.06	0.06	0.06
Total Energy Cost Per Year	\$ 1,843.20	\$ 1,152.00	\$ 1,612.80	\$ 1,612.80	\$ 1,612.80	\$ 2,030.40
Total Operations Cost (30 Years)	\$ 55,296.00	\$ 34,560.00	\$ 48,384.00	\$ 48,384.00	\$ 48,384.00	\$ 60,912.00
Total 30 Year Life Cycle Cost	\$ 172,185.00	\$ 157,140.00	\$ 167,496.00	\$ 169,196.00	\$ 191,396.00	\$ 271,052.00
Overall Rank	4	1	2	3	5	6

1. Maintenance Costs assume Lift Rental @1500 for 1 day, two men @\$60/hr for one day and \$70 per Musco Lamp, \$31 per lamp for 1500W MH (Qualite Pro and Gold, Hubbell), \$106 per lamp for the Qualite International Series and \$25 per lamp for Soft Lighting

2. Demand power cost not included in operational costs

3. Estimated installation costs included to complete life cycle cost. Actual installation costs will vary depending on soils, service location, contractor, etc. Musco costs may be slightly lower because of precast foundations, factory assembled pole top assemblies and other details supplied with their package.

* Soft Lighting Maintenance Costs Include an Additional Relamp Because No Extended Warranty is Available.

Life Cycle Cost Analysis for Sports Lighting Systems

Design Field -- Baseball/Softball	Hubbell Sportsliter	Musco Light Structure Green	Qualite Pro Series	Qualite Gold Series	Qualite International Series	Soft Lighting
Capital Cost						
Sports Lighting Equipment	\$ 72,369.00	\$ 104,000.00	\$ 80,500.00	\$ 88,500.00	\$ 114,500.00	\$ 230,000.00
Extended Warranty (10 years Maintenance)	\$ 8,208.00	included	\$ 9,600.00	\$ 9,600.00	\$ 14,900.00	Not Available
Optional Remote Control	\$ 5,000.00	included	\$ 4,900.00	\$ 4,900.00	\$ 4,900.00	Not Available
Estimated Installation Costs	\$90,000	\$ 90,000.00	\$ 90,000.00	\$ 90,000.00	\$ 90,000.00	\$ 100,000.00
Estimated Total Capital Cost	\$ 175,577.00	\$ 194,000.00	\$ 185,000.00	\$ 193,000.00	\$ 224,300.00	\$ 330,000.00
Maintenance Costs (30 years)						
Relamp Frequency (Based on Supplier Data and 600 hours a year)	5 Years	8.3 Years	5 Years	5 Years	5 Years	6 Years
Number of Relamps Required Beyond the Extended Warranty (from year 10 to year 30)*	4	3	4	4	4	5
Estimated Relamp and Cleaning Costs Each Occurrence (2005 Dollars)	\$ 4,816.00	\$ 5,400.00	\$ 4,444.00	\$ 4,506.00	\$ 9,244.00	\$ 5,684.00
Estimated Total Maintenance Costs (30 Years)	\$ 19,264.00	\$ 16,200.00	\$ 17,776.00	\$ 18,024.00	\$ 36,976.00	\$ 28,420.00
Operations Costs (30 Years)						
No. of Fixtures	76	42	64	66	64	104
Consumption per Fixture kW	1.6	1.6	1.6	1.6	1.6	1.175
Hours of Use Per Year	600	600	600	600	600	600
No. of Years	30	30	30	30	30	30
Cost per Kilowatt (2005 \$)	0.06	0.06	0.06	0.06	0.06	0.06
Total Energy Cost Per Year	\$ 4,377.60	\$ 2,419.20	\$ 3,686.40	\$ 3,801.60	\$ 3,686.40	\$ 4,399.20
Total Operations Cost (30 Years)	\$ 131,328.00	\$ 72,576.00	\$ 110,592.00	\$ 114,048.00	\$ 110,592.00	\$ 131,976.00
Total 30 Year Life Cycle Cost	\$ 326,169.00	\$ 282,776.00	\$ 313,368.00	\$ 325,072.00	\$ 371,868.00	\$ 490,396.00
Overall Rank	4	1	2	3	5	6

1. Maintenance Costs assume Lift Rental @1500 for 1 day, two men @\$60/hr for one day and \$70 per Musco Lamp, \$31 per lamp for 1500W MH (Qualite Pro and Gold, Hubbell), \$106 per lamp for the Qualite International Series and \$25 per lamp for Soft Lighting

2. Demand power cost not included in operational costs

3. Estimated installation costs included to complete life cycle cost. Actual installation costs will vary depending on soils, service location, contractor, etc. Musco costs may be slightly lower because of precast foundations, factory assembled pole top assemblies and other details supplied with their package.

* Soft Lighting Maintenance Costs Include an Additional Relamp Because No Extended Warranty is Available.

RECOMMENDATIONS

Packaged sports lighting systems have proven to be of significant value to owners. Our impressions and recommendations as a result of this study are listed below.

On-Field Lighting Performance

Typically every modern sports lighting system is able to provide lighting levels and uniformities as recommended by the RP-6. In this study, the single exception was Soft Lighting for the baseball field, where uniformities were not achieved for the outfield and poles were positioned in IESNA glare zones. The limitations of Soft Lighting are noted elsewhere in the report.

The major issue facing owners with respect to on-field performance is to retain a knowledgeable electrical engineer with expertise to provide specifications and evaluate submittals to ensure the owner will actually receive the desired performance. Field performance measurements should also be required to verify that the system performs to the specified levels following construction.

Recommendations:

1. Retain an experienced and qualified engineer with specific knowledge of sports lighting systems to perform design task.
2. Specify performance requirements and require performance guarantees for on-field lighting from manufacturers/suppliers.
3. Performance test each field following construction/lamp burn-in for compliance to specifications. Require corrections, without cost to the owner, as needed.

Off Field Lighting/Control of Obtrusive Light

When compared to the typical unshielded fixture of the 1970s and 1980s, today's fixtures with spill and glare control features offer outstanding performance in the control of obtrusive light.

- **Sky Glow** – Fixtures equipped with external visors (or use of flat glass fixtures) can reduce direct light emissions into the air from the fixtures to zero. Even the worst performing fixture evaluated with respect to sky glow had only negligible uplight directly from the fixtures. This is a significant issue with respect to astronomers and others with concerns about preserving views of the darkened nighttime sky.
- **Spill Light** – Every modern fixture is able to reduce spill light to the maximum recommended levels specified by the IESNA at 200 feet from the edge of the design field for an LEZ 3, as confirmed by submittals. Five of the six fixtures evaluated were able to meet spill light recommendations at 200-feet as shown in the table below. The manufacturer did not submit proper information for the Qualite Pro Series, so its performance could not be evaluated. At closer distances, control of spill light varied significantly.

Spill light levels for the soccer field, per the criteria in the request for information are shown below, demonstrating the typical control of spill light by each fixture under established condition. Typical pole locations have been established for a fair comparison. Pole locations are defined in the Appendix.

Spill Light Comparison Maximum Vertical Illuminance (fc) at 5-Feet (Soccer Field)						
Distance (ft) from Edge of the Field	Hubbell Sportsliter	Musco LSG	Qualite Pro	Qualite Gold	Qualite Int'l	Soft Lighting
50	2.93	2.24	*	2.25	**	17.8
150	0.43	0.15	*	0.45	0.3	0.9
200	0.30	0.07	*	0.3	0.2	0.4

* - Indicates not received

** Spill light levels at 100 ft not 50ft required. Levels provided were 0.7fc at 100ft.

- Glare** – Offsite glare is often considered to be the most objectionable form of obtrusive light by facility neighbors and those with views of the luminaires. Glare is directly related to the level of candlepower that is present at the observer point. DMD has found that by limiting candlepower at the property line, glare complaints are minimized. This is a method established in Europe and promoted by the Institution of Lighting Engineers. DMD has established a 12,000 candlepower limit at the property line as a maximum value, and both the method and this limitation have been adopted by the City of Seattle, Washington.

The performance of modern fixtures with respect to limiting off site candlepower was evaluated using candlepower curves for a typical fixture beam spread type. The results showed significant differences between products as illustrated in the *Figure 8-1 – Candle Power Analysis, NEMA 4 x 4 Fixtures* on the following page. If the limitation of offsite glare is a driving factor, fixture selections can be made to significantly limit candlepower at the property line. Note that two of the fixtures could not be evaluated with respect to candlepower analysis as the manufacturer did not submit the information needed in a timely manner, even after multiple requests.

Clearly, based on our analyses, fixtures differ in control of obtrusive light. When control of obtrusive light is an issue at a particular site, the owner may wish to choose a supplier based on “best technology available.”

Recommendations:

- Specify maximum acceptable spill light levels at the property line in accordance with IESNA publication TM-11.
- Specify performance testing of spill light levels per TM-11, and require corrections via re-aiming to provide compliance with the specification, as needed.
- Specify performance requirements with regard to maximum acceptable candlepower at the property line using a Simplified Glare Analysis as part of the submittal process prior to bid to reduce glare complaints.

Constructability

The advent of packaged systems and factory-based assembly and testing has greatly improved constructability and reduced construction-related risks for owner and contractors. Innovations such as pre-aimed fixtures, fully - assembled pole-top assemblies, factory-tested wiring harnesses, precast foundations and factory-tested and wired ballast enclosures are significant innovations that are implemented to varying degrees for all of the system reviewed with the exception of Soft Lighting. Competition continues to result in the application of many constructability-related innovations across the industry.

Recommendation:

- Specify componentized packaged systems that feature factory assembly and testing. Require factory aiming of luminaires.

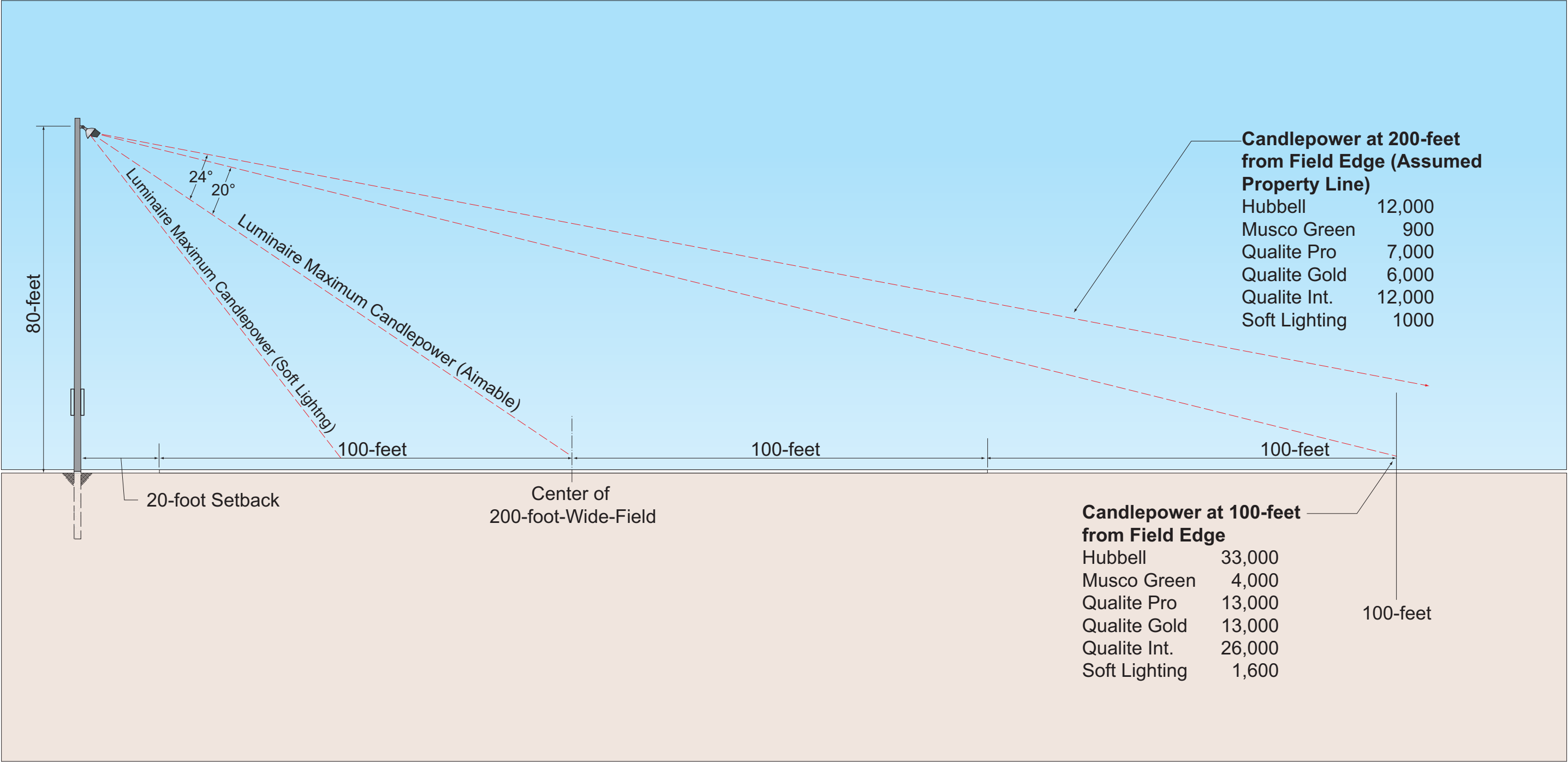


Figure 8-1 – Candlepower Analysis, NEMA 4 x 4 Fixtures

Product Quality

In general the quality of the products used for the systems examined in this study was very good. Minor differences exist in manufacturing and arrangement of the products (crossarm arrangements and mounting, for instance), and there are slight differences in materials selections (such as the gauge of metals, or the choice of ballast enclosure materials). Manufacturers may offer a choice of materials (steel or aluminum) with respect to ballast enclosures and cabinets.

Typically, the use of any of the sports lighting systems evaluated in this study will result in up to 30 years of service, or more.

Submittals should be carefully reviewed to ensure that products with choices of materials or configurations are supplied as specified, and the desires of the owner with respect to product features are met. It is not uncommon, for instance, to specify an aluminum ballast enclosure in project specifications and be provided a steel unit.

Recommendation:

1. Specify corrosion-resistant materials. Specify powder-coated aluminum ballast enclosures and cabinets for reduced maintenance.

Maintenance Considerations

Modern packaged sports lighting systems offer design features that ease the maintenance burden. All manufacturers of aimable systems now offer remote ballast enclosures for easy access, and products feature advanced coatings and finishes that extend life and maintain performance. Manufacturers' designs and guarantees extend to fixture stability over time, minimizing the need for reaming due to vibration- and wind-induced movement. Most luminaire assemblies can be accessed from behind the pole for easy relamping and cleaning. All major manufacturers now offer diagnostic tools to detect electrical faults, and some even offer remote diagnostics.

Typical maintenance activities, excluding component failures, will include periodic relamping and cleaning of the luminaires. Relamping should not take place without cleaning, as dirt accumulation over a four- or five-year period can result in up to 12 percent or more reduction in performance in clean conditions (as defined by the IESNA).

All major manufacturers now offer extended warranties, typically for a 10-year period. These warranties offer comprehensive coverage and complete maintenance of the sports lighting system, including group lamp replacement and cleaning based on hours a specified number of hours of use. Extended warranties can be of value to owners who do not have the maintenance staff or personnel to provide maintenance activities, or who wish to roll the cost of extended maintenance into capital costs.

Recommendation:

1. Specify maintenance-friendly features, such as remote ballasts, fixtures that can be relamped from behind the pole, etc. Evaluate the cost and advantages of extended warranties and purchase when it is determined that the extended warranty provides good value.

Supplier-Provided Lighting Remote Controls

Controls are an important part of any sports lighting system. Remote control units provided by manufacturers offer turnkey integration and proven track records of performance.

Hubbell and Qualite offer a control system provided by Skylogix. This system uses a paging network for communications that has proven to be highly reliable and available. The system can be configured for automatic operation via a desktop computer software package which also provides field usage reports, and also allows for switching by telephone access. An optional keypad can be used to require user input of a key code to turn the lights on subject to the availability programmed by the desktop computer software. More information on the Skylogix system is provided in the Appendix. A monthly service fee is required.